

EPISD Forensic Science



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EPISD Forensics Team
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CONCEPT

1

Unit 1 Safety and Scientific Method

TEKS

(1) The student demonstrates professional standards/employability skills as required by business and industry. The student is expected to:

(A) The students achieve business and industry employability skills standards such as attendance, on-time arrival, meeting deadlines, working toward personal/tram goals everyday, and ethical use of technology.

(2) The student, for at least 40% of instructional time, conducts laboratory or field investigations using safe, environmentally appropriate, and ethical practices. These investigations must involve actively obtaining and analyzing data with physical equipment, but may also involve experimentation in a simulated environment as well as field observations that extend beyond the classroom. The student is expected to:

(A) demonstrate safe practices during laboratory and field investigations; and

(B) demonstrate an understanding of the use and conservation of resources and the proper disposal or recycling of materials.

(3) The student uses scientific methods and equipment during laboratory and field investigations. The student is expected to:

(A) know the definition of science and understand that it has limitations, as specified in subsection (b)(2) of this section;

(B) know that scientific hypotheses are tentative and testable statements that must be capable of being supported or not supported by observational evidence.

(C) know scientific theories are based on natural and physical phenomena and are capable of being tested by multiple independent researchers. Additionally, scientific theories are well-established and highly-reliable explanations, that may be subject to change as new areas of science and new technologies are developed;

(D) distinguish between the use of scientific hypotheses and scientific theories;

(E) plan and create descriptive, comparative, and experimental investigations, including asking questions, formulating testable hypotheses, and selecting equipment and technology;

(F) collect and organize qualitative and quantitative data and make measurements with accuracy and precision using tools such as calculators, spreadsheet software, data-collecting probes, computers, standard laboratory glassware, microscopes, various prepared slides, stereoscopes, metric rulers, electronic balances, gel electrophoresis apparatuses, micropipettors, hand lenses, Celsius thermometers, hot plates, lab notebooks or journals, timing devices, cameras, Petri dishes, lab incubators, meter sticks, and models, diagrams, or samples of biological specimens or structures;

(G) analyze, evaluate, make inferences, and predict trends from data; and

(H) communicate valid conclusions supported by the data through methods such as investigative reports, lab reports, labeled drawings, graphic organizers, journals, summaries, oral reports, and technology-based reports.

(4) The student uses critical thinking, scientific reasoning, and problem solving to make informed decisions within and outside the classroom. The student is expected to:

(A) analyze, evaluate, and critique scientific explanations by using empirical evidence, logical reasoning, and experimental and observational testing, including examining all sides of scientific evidence of those scientific explanations, so as to encourage critical thinking by the student;

(B) communicate and apply scientific information extracted from various sources such as current events, news

reports, published journal articles, and marketing materials;

(C) draw inferences based on data related to criminal activities and acts;

(D) evaluate the impact of scientific research on criminals, or criminal acts and society;

(E) evaluate scientific models regarding their limitations in representing biological objects or events; and

(F) research and describe the history of science and contributions of scientists and criminal justice system.

Objectives

In this chapter, a major emphasis will be placed on:

- Safety
- Scientific method
- Forensics scientific method

Safety

The rationale behind safety is to ensure that all parties are safe due to the hands-on nature of the course. Some rules to follow include:



MEDIA

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Common Procedures

- Become informed by reading through the procedures and follow all instructions.
- Do not touch any equipment, chemicals, or other materials until you are given permission.
- Do not bring food, drinks, or gum in the lab.
- No horseplay is allowed.
- Keep areas clean and do not bring excess materials to the lab stations.
- Know where to find and how to use all safety equipment.
- Use the fume hood if the area is not aerated.



- Notify the instructor if something has gone wrong, and ask questions if there is uncertainty on how to execute a procedure.
- Wash hands after all labs have been completed.
- When using a sharp apparatus, cut away from your body or anybody else's body.

Clothing

- All contact lenses should be removed and safety goggles are to be worn during all labs.
- Make sure long hair is not left loose.
- Remove dangling jewelry and/or clothing.
- Shoes should completely protect the foot.
- Lab aprons must be worn and wear gloves when needed.



Chemicals

- Do not come in contact with, sample, or sniff (use wafting technique) any chemicals, as they are all capable of being dangerous.
- Do not taint unused chemicals by returning used chemicals back into the initial container.
- Keep anything flammable away from fire.
- Always refer to the MSDS when needing additional information on any chemical.

MATERIAL SAFETY DATA	
SECTION 4 - FIRST AID	
act:	Flush with large amounts of water for at least 15 minutes. Do not
act:	Wash affected area gently with soap and water. Skin cream or lotion
:	Do not induce vomiting; drink plenty of water.
n:	Remove affected person to clean fresh air.
	**If any of the symptoms persist, seek medical attention immediately.
SECTION 5 - FIRE FIGHTING MEASURES	
it:	Non-combustible
ing media:	Use extinguishing media appropriate to the surrounding fire.
hazards:	None
ig quipment:	Wear full bunker gear including positive pressure self-contained breathing apparatus.
SECTION 6 - ACCIDENTAL RELEASE MEASURES	
cedures:	Avoid creating airborne dust. Follow routine housekeeping procedures using HEPA filtered equipment. If sweeping is necessary, use a dust suppressant. Do not use compressed air for clean-up. Personnel should wear approved respirator. Avoid clean-up procedures that could result in exposure to dust.
SECTION 7 - HANDLING AND STORAGE	
	Limit use of power tools unless in conjunction with local exhaust ventilation. Frequently clean the work area with HEPA filtered vacuum or air. Avoid accumulation of debris. Do not use compressed air for clean-up.
	This product is stable under all conditions of storage. Store in a cool, dry place.

Equipment

- Never pick up any broken equipment with your hands and place in a broken glass container.
- Do not handle anything electrical if hands are wet or moist.
- Don't use damaged glassware or equipment that may cause electrocution.



- Do not cause drastic changes in temperature when dealing with glass.

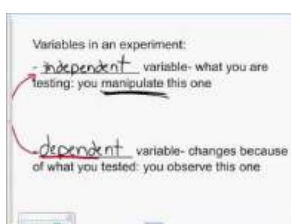
Heat or Flame

- Do not stretch over fire and always ensure that someone is keeping a watchful eye over the flame.
- Proper method of heating a liquid in a test tube:



- Do not gaze into or point any liquid being heated in glassware towards nearby individuals as the contents may spatter.
- Do not touch anything if you are unaware whether the object may be hot.

Traditional Scientific Method



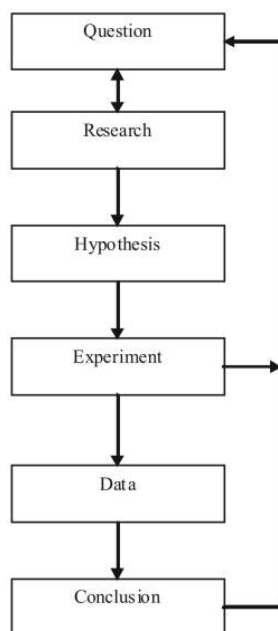
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The scientific method studies the present and is the progression of steps in order to ultimately solve a problem. The steps include:

- State the problem/pose a question
- Gather information.
- Form a hypothesis.
- Plan and perform an experiment.
- Analyze data.
- Draw conclusions.



State the Problem /Pose a Question

There needs to be a reason for initiating an experiment. It usually begins with an inquisitive question that wants to be answered, or trying to find a solution to a problem. Another important factor is that it has to be something that may actually be tested.



Gather Information

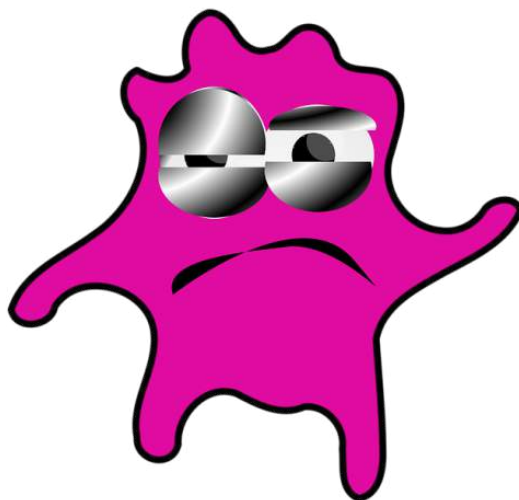
The person that poses the question needs to be able to make observations and draw inferences. An **observation** is made when one or more of the senses are used to learn something. An **inference** is when an explanation is applied to the observation. The only way that this can be done is by spending ample time researching the topic. Research may be done in various ways which include internet searches, reading books, articles, encyclopedias and magazines, watching educational videos, and interviewing people educated in the matter at hand.



Form a Hypothesis

A **hypothesis** must be assembled, which is a possible answer to the problem or question. A hypothesis is best composed when there is an “if” and “then” statement. The “if” part of the statement, is what is genuinely being tested. The “then” part of the statement is what the outcome is perceived to be. For example, if bacteria are exposed to increasing temperatures, then the bacteria will gradually die until they no longer exist.





Plan and Perform an Experiment

There needs to be a way in which the hypothesis will be tested. This will entail devising an actual experimental procedure. A **variable** is anything that can change throughout the experiment such as time, equipment, and temperature. In a true scientific experiment, only one variable may change at a time and everything else must stay constant, which is a **controlled experiment**. If various variables are changed, the cause of the experiment will never be known.

Two other terms that need to be discussed are independent and dependent variables. An **independent variable** is what is actually being tested. The **dependent variable** is the outcome that is expected. In the bacteria hypothesis example stated above, the independent variable would be the “if” part of the statement, which is temperature. The “then” part would then be the dependent variable, which is bacterial demise.

A sketch may be constructed to start to visualize what the experiment may look like. Equipment and/or supplies need to be collected. The steps then need to be organized so that the experiment can flow smoothly. An implementation of an experimental group and a control group must not be forgotten. The **experimental group** will be the group that acquires the independent variable. This is the group that is actually being tested. The **control group** will be set up exactly the same as the other group, but this group will not be given the item being tested. This group is simply there as a standard of comparison. The only point that is left to focus on now is the running of the experiment.

Once an experiment has been performed, it may be wise to repeat the experiment various times. Several trials help to show consistency. These reliable values help to strengthen that the conclusion will be valid.



Analyze Data

After the experiment has been conducted, all that is left is the interpretation of the results. Data may be compiled into charts, graphs and diagrams. This will help to organize information to make it easier to see any relationships or trends in the results. Two types of data that may be acquired are qualitative and quantitative data. **Qualitative data** is data that cannot be measured with numbers. **Quantitative data** is numerical information gathered from the experiment that can be studied mathematically.



Draw Conclusions

The very last detail is to take all the information from the experiment to determine whether or not the hypothesis is correct. If the hypothesis is wrong, it could possibly lead to a new, better developed hypothesis, where another experiment could be conducted. If it is right, other scientists may want to explore their findings, so the results may be published in a scientific magazine or journal. These scientists may want to replicate the experiment to confirm the results. If many people repeatedly test and confirm the same outcomes, the hypothesis may turn into an explanation called a **theory**.



Forensics Scientific Method



Forensics scientific method is slightly different from the traditional scientific method. The traditional scientific method studies a possible problem or question to come up with a solution in the present, whereas forensics will need to apply the scientific method to study an event that has already taken place.

Forensics starts with a problem, such as a woman found shot with a 9 mm caliber at her home. Investigators will then collect any eyewitness statements and physical evidence seen at the crime scene. A hypothesis is formulated as to who could have committed the crime. Instead of planning an experiment, testing of evidence will be the next step. An autopsy is performed; and forensic analysis of evidence is executed such as ballistics and toxicology. An examiner then compares the eyewitness statements and the findings of the physical evidence. All results of forensic examinations are analyzed and verified to ensure that there will not be an injustice of any sort. This information is taken to court in order to prosecute the person accused of committing the crime. The last step is to conclude who was responsible for the crime and to convict or exonerate the individual. A conviction will lead to a sentence. If the results do not verify the initial person it was thought to be that committed the crime, the process will be repeated until somebody is held responsible for the crime.



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Chapter Summary

- The rationale behind safety is to ensure that all parties are safe due to the hands-on nature of the course.
- The traditional scientific method studies a possible problem or question to come up with a solution in the present.
- Forensics will need to apply the scientific method to study an event that already has taken place.
- The steps of the traditional versus forensics scientific method vary slightly.

Review Questions

1. An advertisement claims that patients can defeat the common cold in 48 hours by taking over the counter Zicam tablets. Which is the dependent (result of the experiment) variable to test the claim?
2. A student is injured by inhaling gases released during a laboratory experiment. Which piece of equipment could have prevented this accident?
 - A. eyewash
 - B. fire blanket
 - C. goggles
 - D. fume hood
3. In a scientific experiment, how many independent variables should be tested at the same time?
 - A. none
 - B. one
 - C. two
 - D. three
4. What is an example of quantitative data?
5. Students in a science class want to design an investigation to determine if a fertilizer added to soil affects the height of a plant over time. Which items would the students need to complete this investigation?
 - A. ruler, calculator, plant, soil samples with different amounts of fertilizer
 - B. microscope, beaker, plant, soil samples with the same amount of fertilizer
 - C. computer, stopwatch, plant, soil samples with different amounts of fertilizer
 - D. tape measure, graph paper, plant, soil samples with the same amount of fertilizer
6. Juan thinks that water will evaporate faster in a warm place rather than a cool place. He has two identical bowls and a bucket of water. He wants to perform an experiment to find out if he is correct. Which procedure should he follow?
 - A. Place both bowls with the same amount of water in a warm place.
 - B. Place a bowl of water in a cool place and a bowl with twice the amount of water in a warm place.
 - C. Place a bowl of water in a cool place and a bowl with half the amount of water in a warm place.
 - D. Place a bowl of water in a cool place and a bowl with the same amount of water in a warm place.
7. Solvents used in chromatography are often flammable. Which of the following should NOT be allowed in the room when chromatography is performed?
 - A. fire extinguisher
 - B. hot plates
 - C. open flames

D. computer

8. The neighbor heard a man and woman arguing, and saw a man fleeing the scene moments after she heard complete silence. She called 911, and ten minutes later, the police show up at the scene. A woman is found strangled in her home. They question the witness, she gives her account of what occurred, and they then search for physical evidence. Based on the eyewitness account and evidence found, they believe that the suspect is her ex-husband. Evidence is taken to the lab and is tested and seems to correlate with the eyewitness statement. The data revealed is consistent with her ex-husband and now it is time to determine whether he is guilty or innocent in a court setting. Which statement above shows the analysis phase of the scientific method?

9. The difference between an experimental group and a control group is that the

- A. experimental group has a known outcome.
- B. experimental group contains the variable being tested.
- C. control group contains no variables being tested.
- D. control group is needed only when testing more than one variable.

10. Why is it important to conduct a scientific experiment multiple times?

Please visit the following website for the Flinn Scientific safety exam: http://www.flinnsci.com/media/396492/safety_exam_hs.pdf

CONCEPT

2

Unit 2 Forensics Intro, History, & Careers

Unit 2 Forensics Intro, History, Careers

TEKS

- Evaluate the impact of scientific research on society and the environment. [3D]
- Research and describe the history of science and contributions of scientists. [3F]
- Distinguish between forensic science and criminalistics in law, public safety, corrections, and security. [4A]
- Identify roles, functions, and responsibilities of forensic science professionals. [4B]
- Summarize the ethical standards required of a forensic science professional. [4C]
- Present career information in written and verbal formats. [4D]
- Recognize the major contributors to the development of forensic science. [4E]
- Illustrate the history of forensic science. [4F]



Forensic Science is a field of study where the sciences are applied to both criminal and civil law, therefore making the forensic scientist an integral member of the criminal justice system. It is important to note that an understanding of the history and current development of the different fields and careers within the scope of forensic science is needed in order for the marriage of science and law to be an effective tool. In order for an individual to make an informed decision as to which career path to choose within the forensic sciences it is important to understand the different career options that range from working in the field, the laboratory and or the courtroom.

In forensic science, experts in their respective fields use the scientific method to gather and examine evidence from a crime scene in order to reconstruct the crime, which is then used to bring justice to the victim and penalize the perpetrator in a court of law. The same concept was performed in ancient Rome. The word forensic originates its Latin root of *forensis*, which was a term used throughout the Roman empire when those charged of a criminal offense would appear “before the forum” or *forensis*. It is documented that the both the victim and the suspect would present their case in front of a public, who would ultimately decide their fates.

Objectives

The students will be able to:

- Identify the major contributors to the development of forensic science.
- Examine a historic time line of forensic science.
- Distinguish between forensic science and criminalistics in law, public safety, corrections, and security.
- Identify the roles, functions, and responsibilities of forensic science professionals.
- Explore and identify various fields of expertise in forensic science.
- Discuss the different education and training requirements for the various careers in forensic science.



History of Forensic Science

History and Development of Forensic Science.

One of the earliest records of the application of forensic science dates back to the third century in China. The records document a case where a woman had claimed that her husband accidentally died in their house as it went up in flames, the woman was able to escape to tell the story. The coroner did not believe the wife and decided to perform an experiment using two pigs. In the experiment the coroner burned one pig alive and then burned the other pig that was already dead. The coroner noticed that the pig that was burnt alive had ashes inside its mouth as it probably

inhaled them, while the dead pig did not. The coroner then went back to the deceased husband and found no ashes inside the man's mouth, therefore deducing that the man was already dead, the wife was brought into questioning and she confessed to murdering her husband and burning his body in the house fire to make it look like an accident and to destroy any evidence that may have brought light to her wrong doing.

There are certain key points that should be mentioned when examining the history and development of forensic science as a field within the criminal justice system which uses many other science disciplines in their investigations. It is the scientific method of gathering and examining information, which has been the cornerstone of all scientists and for that matter forensic scientists as they gather, examine and test evidence found at a crime scene with the purpose of solving a criminal case in a court of law.



For example beginning in the early 19th century advancements in the medical field enabled medical examiners (coroners) to determine causes of death when it came to suspicious deaths. On the same token, the further development of microscopes, allowed for trace evidence examination. Also the development of chemical tests in the 19th century allowed for more evidence testing.



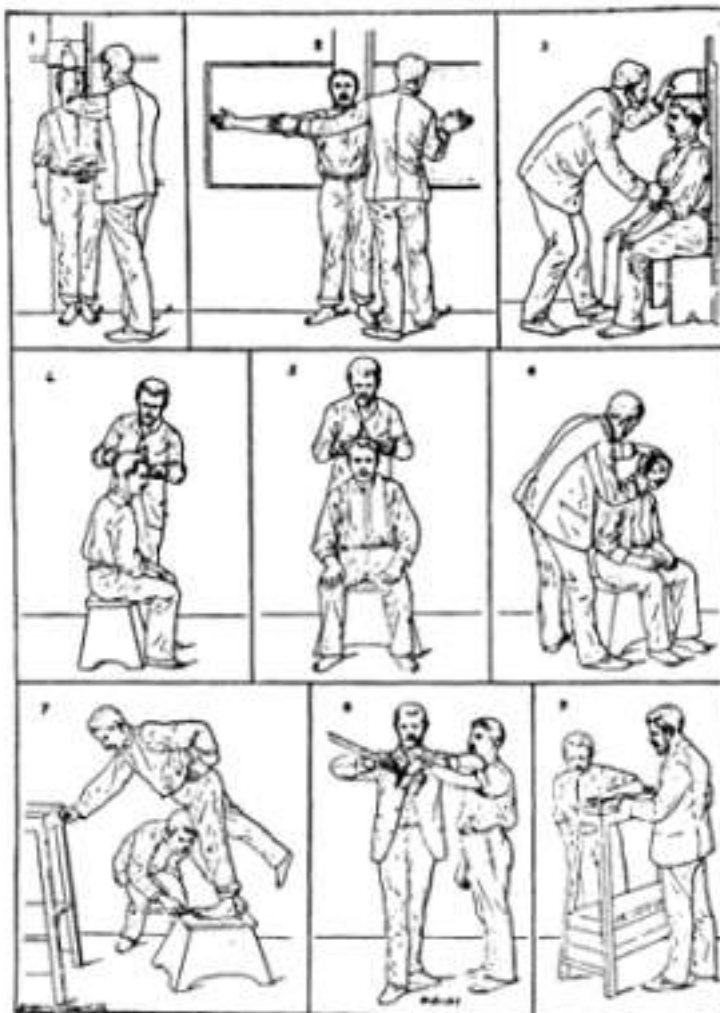
Mathieu J. B. Orfila (1787-1853) Is one of the most renowned forensic scientists of the 19th century. In 1814 Mathieu Orfila, published articles on the detection of poisons and effects. He is best known for his involvement in

the “Lafarge” arsenic poisoning case in France, where he detected arsenic in LaFarge’s body, thus proving that he was murdered by his wife. He is often referred to as the “father of forensic toxicology”.



In 1879 **Alphonse Bertillon** (1853-1914) , a French anthropologist, introduced the Bertillon System, also called Anthropometry.

RELEVÉ DU SIGNALEMENT ANTHROPOMÉTRIQUE



1. Taille. — 2. Envergure. — 3. Buste. —
4. Longueur de la tête. — 5. Largeur de la tête. — 6. Oreille droite. —
7. Pied gauche. — 8. Mésius gauche. — 9. Coudée gauche.

It was a system of identifying people by their physical appearance. Various measurements were taken and recorded from various parts of the body. It was considered to be the most accurate method of personal identification until the Will West case in 1903.



Hans Gross (1847-1915) is considered by many in the field as the “Father of Forensic Publications”. He was a magistrate and law professor in Austria and is known for his publications and for introducing the word “criminalistics”. In 1893, published a Handbook for Magistrates that greatly influenced the practice of criminal investigations.



The most influential figure in 19th century forensic science was “**Sherlock Holmes**,”



the fictional character created by **Sir Arthur Conan Doyle**. His influence can be compared to the popularity of modern crime scene investigation television shows.



In the beginning of the 20th century anthropometry was put to the test. In 1903 Kansas State Prison incarcerated two individuals by the name of Will West. They both had identical facial features and body measurements. The problem came when the wrong prisoner was released, this led to the end of anthropometry and the beginning of acceptance for fingerprinting.



Another significant discovery came in 1901 with the discovery of antibodies in the blood, which led to the discovery of blood typing by **Karl Landsteiner** in 1901.



In 1913 Locard's Exchange Principle is established. It is named after **Edmond Locard** (1877-1966); a French police officer who establishes the first police crime laboratory in Lyon. The Principle states that whenever two objects come into contact, trace materials are exchanged between the two. Exchange occurs even if the material is too microscopic to be detected. Therefore, Locard strongly believed that every criminal can be connected to a crime by dust particles carried from the scene.



History of Crime Labs in the US

The first crime lab in the United States was in the city of Los Angeles established in 1923. Soon after the University of California at Berkeley Criminalistics Department was opened and led by Dr. Paul Kirk. In 1932 the FBI National Laboratory opened under Director J. Edgar Hoover. In 1981 the FBI Forensic Science Research & Training Center opened five Federal Crime Labs in the USA. They are The FBI Laboratory the Drug Enforcement Administration (DEA) Laboratories analyze drugs seized in violation of federal laws, the Bureau of Alcohol, Tobacco, Firearms and Explosives (ATF) Laboratories analyze alcoholic beverages, weapons, and explosive devices, the U.S. Postal Inspection Services Laboratories, and the United States Army Criminal Investigation Laboratory (USACIL).

Local Crime Labs

One of the earliest crime labs in Texas is the Houston Police Department Crime Laboratory. There is also the Medical Examiner's office in Harris County Medical. Texas Department of Public Safety Forensic Laboratories has its headquarters located in Austin, TX, with fourteen other locations including El Paso, Houston, Abilene, Amarillo, Corpus Christi, Garland, Lubbock, and Tyler.

Other key points in the History of forensic science

Pre-700 BC – Fingerprints are used on clay tablets for business transaction in ancient Babylon.

287-212 BC – Archimedes proves the crown was not made of gold using density and buoyancy.

250 BC – Erasistratus, an ancient Greek physician, discovers that his patients' pulse rates increase when they are telling lies. The first Polygraph?

1235 – Sung Tzu and the bloody sickle. A murder was committed using a sickle. All those in the village who owned a sickle were made to bring them out and lay them in the sun. Eventually flies gathered on one particular sickle, identifying it as the murder weapon.

1248 – The Chinese book, "The Washing Away of Wrongs" describes how to distinguish drowning from strangulation.

1302 – Bartolomeo da Varignana performs an autopsy in the case of suspected murder of a nobleman.

1447 – The missing teeth of the French Duke of Burgundy are used to identify remains.

1786 – John Toms of Lancaster, England is convicted of murder on the basis of a torn wad of paper found in a pistol matching a remaining piece in his pocket. One of the first documented uses of physical matching.

1835 – Henry Goddard of Scotland Yard first uses bullet comparison to catch a murderer. The comparison was based

in a visible flaw in the bullet, traced back to a mold.

1836 – English chemist James Marsh develops a test for the presence of arsenic in tissues, known as the Marsh Test, and is the first to use toxicology in a jury trial.

1889 – Forensic medicine professor Alexandre Lacassagne attempts to individualize bullets to a gun barrel, based on the number of lands and grooves.

1892 – Sir Francis Galton publishes his book “Fingerprints”, establishing the individuality of fingerprints and a first classification system.

1892 – Juan Vucetich develops the fingerprint classification system that comes to be used in Latin America.

1896 – Sir Edward Richard Henry develops the print classification system that would later be used in Europe and North America.

1901 – Sir Edward Richard Henry is appointed head of Scotland Yard and forces fingerprint identification to replace anthropometry.

1901 – Leone Lattes discovers that blood can be grouped into different categories..

1905 – US president Theodore Roosevelt establishes the Federal Bureau of Investigation (FBI).

1915 – Professor Leone Lattes develops the first antibody test for ABO blood types.

1920s – American criminalist Luke May pioneers striation analysis in tool mark comparison.

1920s – Calvin Goddard, with others, perfects the comparison microscope for use in bullet comparison.

1923 – In the case *Frye v. US*, polygraph test results are ruled inadmissible.

1924 – August Vollmer of LA, California implements the first US crime laboratory.

1937 – Walter Specht develops the chemiluminescent reagent luminal as a presumptive test for blood.

1940s – Dental records are compared with teeth from corpses.

1945 – Frank Lundquist develops the acid phosphatase test for semen.

1950 – Max Frei-Sulzer develops the tape lift method of collecting trace evidence.

1950 – The American Academy of Forensic Science (AAFS) is formed.

1953 – James Watson and Francis Crick publish a landmark paper identifying the structure of DNA.

1954 – R. F. Borkenstein invents the Breathalyzer for field sobriety testing.

1955 – De Saram publishes measurements of temperature in cases obtained from executed prisoners. The papers are considered landmarks in determination of time since death from body cooling.

1957 – Mocker and Stewart develop skeletal growth stages.

1959 – Harrison and Gilroy introduce a qualitative colorimetric chemical test to detect the presence of barium, antimony and lead on the hands of individuals who fired a firearm.

1960 – Lucas describes the application of gas chromatography to the identification of petroleum products in the forensic laboratory and discusses potential limitations of the brand identity of gasoline.

1971 – Culliford publishes *The Examination and Typing of Bloodstains in the Crime Laboratory*.

1977 – The FBI introduces the beginnings of its Automated Fingerprint Identification System (AFIS) with first computerised scans of fingerprints.

1977 – Fuseo Matsumur notices his own fingerprints developing on microscope slides, and relates the information to co-worker Masato Soba, who would later be the first to develop latent prints using Superglue fuming.

1984 – Sir Alec Jeffreys discovers a method of identifying individuals from DNA – Restriction Fragment Length Polymorphism (RFLP), dubbed DNA Fingerprinting.

1986 – DNA is used for the first time to identify Colin Pitchfork as the murderer of two young girls in the English Midlands.

1987 – DNA profiling is introduced for the first time in a US criminal court.

1996 – The FBI introduces AFIS.

1996 – Mitochondria DNA evidence is used in court for the first time in the US.

1998 – An FBI DNA database, NIDIS, is put into practice.

Other notable forensic scientists

David R. Ashbaugh (1946–), Michael Baden (1934–), William M. Bass (1928–), Alexandre Beaudoin (1978–), Joseph Bell (1837–1911), Sara C. Bisel (1932–1996), Francis Camps (1905–1972), Brian E. Dalrymple (1947–), Wilfrid Derome (1877–1931), Ellis R. Kerley (1924–1998), Paul L. Kirk (1902–1970), Wilton M. Krogman (1903–1987), Alexandre Lacassagne (1843–1924), Henry Lee (1938–), William R. Maples (1937–1997), Pierre Margot (1950–), Miklós Nyiszli (1901–1956), Albert S. Osborn (1858–1946), Skip Palenik (1946–), Kathy Reichs (1950–), Archibald Reiss (1875–1929), Keith Simpson (1907–1985), Clyde Snow (1928–), Sir Bernard Spilsbury (1877–1947), Werner Spitz (1926–), Auguste Ambroise Tardieu (1818–1879), Paul Uhlenhuth (1870–1957), and Cyril Wecht (1931–).

Forensic science key terms

Criminalistics – the application of science in collecting and analyzing physical evidence in criminal cases (court of law)

Crime Scene Investigator – processes crime scenes to collect and preserve physical evidence

Forensic Photographer – uses photographic techniques to document crime scenes and evidence, as well as provide image enhancements and exhibits for analysis and courtroom presentation

Trace Evidence Examiner – identifies and/or compares physical evidence through chemical, physical, and instrumental analysis

Latent Print Examiner – processes and examines latent fingerprints in criminal cases

Forensic Serologist/Forensic Biologist – processes, compares, and/or identifies biological evidence in criminal cases

Forensic Toxicologist – examines body fluids and organs to determine the presence of drugs and poisons

Questioned Document Examiner – studies the handwriting and typeface on questioned documents to determine their authenticity and/or origin

Firearm Examiner – examines firearms and discharged ammunition; also conducts distance determination and tool mark examination

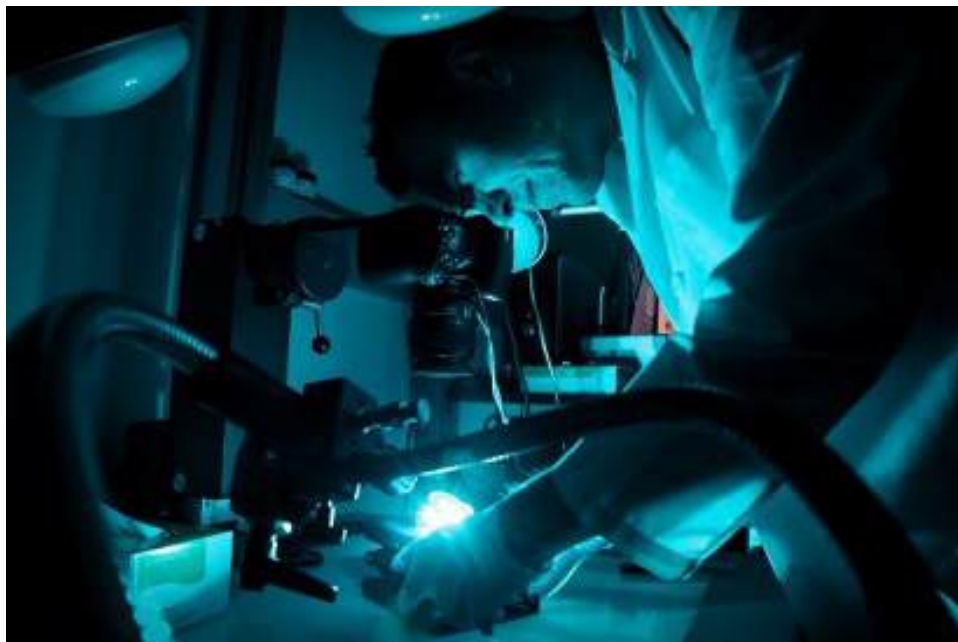
Forensic Entomologist – studies insects to estimate the time of death

Forensic Computer Science – collects and identifies data from computers and other digital devices

Forensic Engineering – concerned with failure analysis, accident reconstruction, and causes and origins of fires or explosions

Forensic Odontology – identifies and compares dental evidence in criminal cases

Forensic Pathology – a branch of medicine used for legal purposes and concerned with determining causes of death



Specialized Departments in Forensic Science

- **Art Forensics** concerns the art authentication cases to help research the work's authenticity. Art authentication methods are used to detect and identify forgery, faking and copying of art works, e.g. paintings.
- **Criminalistics** is the application of various sciences to answer questions relating to examination and comparison of biological evidence, trace evidence, impression evidence (such as fingerprints, footwear impressions, and tire tracks), controlled substances, ballistics, firearm and tool mark examination, and other evidence in criminal investigations. In typical circumstances evidence is processed in a Crime lab.
- **Digital Forensics** is the application of proven scientific methods and techniques in order to recover data from electronic / digital media. Digital Forensic specialists work in the field as well as in the lab.
- **Forensic Anthropology** is the application of physical anthropology in a legal setting, usually for the recovery and identification of skeletonized human remains.
- **Forensic Archeology** is the application of a combination of archaeological techniques and forensic science, typically in law enforcement.
- **Forensic Botany** is the study of plant life in order to gain information regarding possible crimes.
- **Forensic Chemistry** is the study of detection and identification of illicit drugs, accelerants used in arson cases, explosive and gunshot residue.
- **Forensic Dactyloscopy** is the study of fingerprints.
- **Forensic document examination** or questioned document examination answers questions about a disputed document using a variety of scientific processes and methods. Many examinations involve a comparison of the questioned document, or components of the document, with a set of known standards. The most common type of examination involves handwriting, whereby the examiner tries to address concerns about potential authorship.
- **Forensic DNA Analysis** takes advantage of the uniqueness of an individual's DNA to answer forensic questions such as paternity/maternity testing and placing a suspect at a crime scene, e.g. in a rape investigation.
- **Forensic Engineering** is the scientific examination and analysis of structures and products relating to their failure or cause of damage.

- **Forensic Entomology** deals with the examination of insects in, on and around human remains to assist in determination of time or location of death. It is also possible to determine if the body was moved after death using entomology.
- **Forensic Geology** deals with trace evidence in the form of soils, minerals and petroleum.
- **Forensic Odontology** is the study of the uniqueness of dentition, better known as the study of teeth.
- **Forensic Pathology** is a field in which the principles of medicine and pathology are applied to determine a cause of death or injury in the context of a legal inquiry.
- **Forensic Psychiatry** is a specialized branch of psychiatry as applied to and based on scientific criminology.
- **Forensic Psychology** is the study of the mind of an individual, using forensic methods. Usually it determines the circumstances behind a criminal's behavior.
- **Forensic Serology** is the study of the body fluids.
- **Forensic Toxicology** is the study of the effect of drugs and poisons on/in the human body.
- **Trace Evidence analysis** is the analysis and comparison of trace evidence including glass, paint, fibres and hair (e.g., using micro-spectrophotometry).
- **Blood Spatter Analysis** is the scientific examination of blood spatter patterns found at a crime scene to reconstruct the events of the crime.

Careers in forensic science

- Forensic Scientists (also called criminalists, crime lab scientists, etc.)
- Criminologists or Criminal Profilers
- Crime Scene Investigators
- Medical Examiners
- Coroners
- Prosecutors (also called District Attorneys and Assistant District Attorneys)

Qualifications for employment

- Forensic Scientists – Bachelor of Science (BS) or higher in natural or physical science
- Criminologists – BS or higher in sociology or psychology
- Crime Scene Investigators – law enforcement officers with a certification, such as one from the International Association for Identification (IAI)
- Medical Examiners (ME) – licensed pathologists possessing a Doctor of Medicine (MD) that have completed several years of internship in pathology
- Coroners – equivalent to MEs in some jurisdictions; some are elected county officials who handle corpse and death investigation
- Prosecutors – Doctor of Jurisprudence (JD) in criminal law

Certifications and accreditations

- American Society of Crime Laboratory Directors-Laboratory Accreditation Board (ASCLD-LAB) accredits crime laboratories
- International Organization for Standardization (ISO) or ISO 17025 certifies crime laboratories
- American Board of Criminalistics (ABC) certifies scientists
- American Society for Testing and Materials (ASTM) certifies materials used in testing

Specialized duties

- Forensic Scientists – identify and/or compare physical evidence through chemical, physical, and instrumental analysis
- Criminologists – study criminal and behavioral psychology to aid in criminal investigations

- Crime Scene Investigators – collect and preserve physical evidence from crime scenes
- Medical Examiners – perform autopsies to identify the causes and manners of death
- Coroners – typically transport corpses from the crime scene to the morgue; some aid in death investigations
- Prosecutors – initiate arrests, indictments, and prosecution of criminals

Training

- College education
- Internship
- In-house training provided by the employing agency

Conclusion

Forensic science is a multidisciplinary science that works within the boundaries of the legal system to aid in the solving of crimes and civil suites. It is important to recognize the founding pioneers in forensics and their accomplishments so that we can have a better understanding of what is expected of a forensic scientists and the burden that is laid out to gather, examine, and analyze the evidence from a crime scene to be able to reconstruct the crime and give testimony in court. Since Forensic science is multidisciplinary, there are many different career paths one can take to be part of a forensic team. The forensic team works hand in hand with law enforcement officials, prosecutors, and the courts to ensure that the law is upheld and justice is done.

Videos

Forensic Science Timeline

https://www.youtube.com/watch?v=TbuTirBdZjQ&feature=player_detailpage

Forensic Sciences

https://www.youtube.com/watch?v=epRcZL1KI2Y&feature=player_detailpage

Forensic Scientist (Job Overview)

https://www.youtube.com/watch?v=tM-0tt9PB70&feature=player_detailpage

History of Forensic Science Review Questions

Multiple Choices:

1. Which of the following has developed a national system of regional labs under the direction of the government's Home Office?
 - a. Britain
 - b. Japan
 - c. The United States
 - d. Canada
2. In 1923, opened the first crime laboratory in the United States.
 - a. Arizona
 - b. Texas
 - c. New York
 - d. California

3. Who stated in his principle that whenever objects come in contact with each other, there is a cross-transfer/exchange of evidence?
- a. Mathieu Orfila
 - b. James Marsh
 - c. Edmond Locard
 - d. Hans Gross
4. In 1932, the FBI Laboratory was opened by:
- a. Paul Kirk
 - b. J. Edgar Hoover
 - c. Herbert Hoover
 - d. Edmond Locard
5. Who published Criminal Investigation, in which he discussed the benefits of the use of science in crime investigations.
- a. Hans Gross
 - b. Edmond Locard
 - c. Alphonse Bertillon
 - d. Karl Landsteiner

Short Answers:

6. Who is known as the Father of Toxicology? What accomplishment is he recognized for?
7. What is Anthropometry?
8. Name the 5 federal crime laboratories in the United States.

CONCEPT 3

Unit 3 Basics of Law and Value of Evidence

Unit 3 Basics of Law/Value of Evidence

TEKS:

- In all fields of science, analyze, evaluate, and critique scientific explanations by using empirical evidence, logical reasoning, and experimental and observational testing, including examining all sides of scientific evidence of those scientific explanations, so as to encourage critical thinking by the student. [3A]
- Communicate and apply scientific information extracted from various sources such as current events, news reports, published journal articles, and marketing materials. [3B]
- Draw inferences based on data related to promotional materials for products and services. [3C]
- Evaluate the impact of scientific research on society and the environment. [3D]
- Evaluate models according to their limitations in representing biological objects or events. [3E]
- Research and describe the history of science and contributions of scientists. [3F]
- Identify roles, functions, and responsibilities of forensic science professionals. [4B]
- Summarize the ethical standards required of a forensic science professional. [4C]
- Apply knowledge of the elements of criminal law that guide search and seizure of persons, property, and evidence. [5D]
- Describe the elements of a crime scene sketch such as measurements, compass directions, and scale of proportion, legend, key, and title. [5E]
- Develop a crime scene sketch using triangulation, rectangular coordinates, straight-line methods, and use of coordinates on transecting baseline. [5F]
- Outline the chain of custody procedure for evidence discovered in a crime scene. [5G]

Objectives

- Identify the ethical standards that all scientists must abide by.
- Evaluate the methods of processing and analyzing trace evidence found at a crime scene.
- Understand the procedures of evidence collection while maintaining the integrity of a crime scene.
- Understand the difference between criminalistics and forensics.
- Identify the legal responsibilities of forensic science professionals in and out of the courtroom.
- Understand the function of evidence within the scope of the legal system.



Forensic Science is a significant tool used by law enforcement and the courts to resolve civil and criminal matters in our society. These scientists examine the evidence found at the crime scene and determine its value to an investigation through scientific analysis, interpretation/evaluation of their findings, and finally arriving to their conclusion. The findings are then given to the law enforcement investigators and to the court system to aid in their case. It is vital that the findings are truthful and carried out with as much reliability and validity as possible, therefore ethical standards are vital to the scientific process. It is also crucial that the crime scene investigators and forensic scientists are on the same page when it comes to the significance of the evidence; from the crime scene to the courtroom. So that evidence is not corrupted, the partnership between law enforcement and scientists is essential. For example, crime scene evidence may travel through many different departments within a forensic crime scene team due to the many different divisions within forensic science as well as the different departments within law enforcement. Therefore, understanding the need to protect the evidence and developing a chain of custody is necessary for functioning productively and effectively within the legal system.



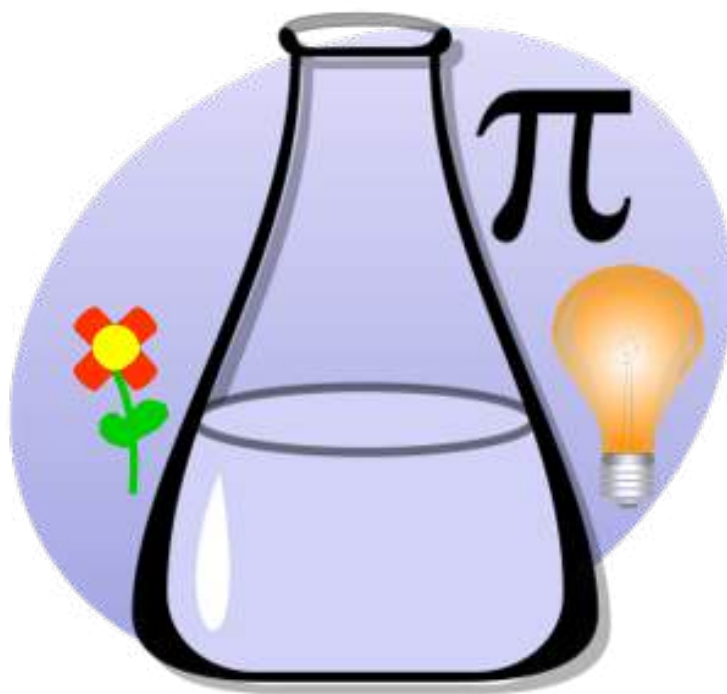
What is Ethics?

Ethics is the study of the rules of behavior based on ideas about what is morally good and bad. Morals are specific and generally agreed upon standards of conduct considered by a society. Therefore, ethics are a guide to problem solving within a profession, like Forensic science.



Ethics in Criminal Justice

Justice is defined as the fair and equitable treatment of all individuals under the law, results in using societies Laws to fairly judge and punish crimes and criminals. The criminal justice profession should be based on the principles of fairness, equality, and impartiality. Law enforcement officers, who serve and protect the public, have a great responsibility to society. It is within their power to initiate the criminal justice process or not initiate the criminal justice process. Criminal justice professionals must work as a team with politicians, legal institutions, courts, and the society at large to address issues that others are not called on to address. Criminal justice practitioners are trained to follow the common standards of natural law. Natural law is the sanction that regulates behaviors of people on the basis of universal traits and common experiences. Natural law is comparable to common law, civil law, and religious law. Natural law guides natural human rights, such as life, liberty, and freedom. The ethical implication of natural law is to maintain dignity equally, regardless of whether practitioners agree on the process. Understanding the concept of natural law allows police to follow a hierarchical order of virtues (for example, human, American, and professional).



Ethics in Science

Scientists observe, analyze and perform experiments in a systematic manner, by abiding to the Scientific method. Most experimentation is performed in a lab setting, where all variables are controlled by the scientists. This is where ethics becomes an integral tool so that there is a check against unethical scientists that can manipulate their results to support their own agenda, therefore, scientific knowledge is replicated by other scientists after it has been researched and published to offer validity and reliability.

Laboratory Ethics

Forensic science is applied science within a legal setting, using forensic evidence to prove or disprove facts in question in a court of law. Typically, forensic science professionals are scientists who have been trained in the sciences such as chemistry, biology, and physics.



Crime Scene and Forensic Laboratory Ethics

Crime scene investigators are responsible for documenting the scene and preserving and collecting evidence, and have to take the necessary precaution to avoid mistakes that may taint the Crime scene. Careful documentation of evidence as well as a set standard for collection procedures may prevent some of the errors associated with evidence handling and collection. Documenting the chain of custody from the crime scene into the forensic laboratory for scientific analysis also ensures reliability and ethical behavior amongst all involved.

Forensic Scientific Method

Observe a problem or questioned evidence and collect objective data. Consider a hypothesis or possible solution. Examine, test, and then analyze the evidence. Determine the significance of the evidence. Formulate a theory based on evaluation of the significance of the evidence

Criminalistics vs. Criminology

- Criminalistics is the scientific examination of physical evidence for legal purposes.
- Criminology includes the psychological angle, studying the crime scene for motive, traits, and behavior that will help to interpret the evidence

The Law within the scope of Forensic science

Forensic science is an integral part of the legal system by adding the element of science in solving criminal and civil matters in a court of law. It gives the legal system another tool to link suspects to a crime and also to exonerate the innocent from any wrong doing. When processing the evidence from a crime scene the forensic specialists will recognize the evidence at the crime scene, make sure to preserve the evidence and keep it away from contaminating agents, and finally to analyze the evidence to determine if it is significant to the case.



The legal and ethical responsibilities of Forensics

As a scientist, all forensic specialists must abide by the scientific method, but forensic specialists must also deal within the parameters of the legal system. Therefore, forensic scientists have to follow all legal procedures and rules when gathering and examining evidence. Within the legal system the forensic scientist's main function is to analyze the evidence in an impartial and scientific manner, to be able to interpret the results so as to arrive to a conclusion, and finally the forensic scientist will either give their report to the detective in charge or to testify in a court of law.

Laws that Pertain to the U.S. Criminal Justice System

When a forensic scientist collects, analyzes, and presents its findings to the legal system, the laws that govern the land must be obeyed. Those Laws begin with The U.S. Constitution as well as the rights given to every citizen by the Bill of Rights. Other laws which make up the boundaries for which all forensic scientists must work within are Statutory Law, Common Law or Case Law, Civil Law, Criminal Law, Equity Law, and Administrative Law.

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- **The Constitution of the United States of America** is a living document that embodies the fundamental laws and principles by which our land is governed. It later supplemented by the Bill of Rights and other amendments. It was originally comprised of seven articles, which embody the national frame of government. Its first three articles give us the doctrine of the separation of powers, Articles four, five, and six describe the rights and responsibilities of state governments and of the states in relationship to the federal government. Article seven establishes the procedure of elections, subsequently used by the thirteen states to ratify it.



- **Bill of Rights** is a list of the most important rights afforded to the citizens of a country, to protect against infringement from public officials and other citizens. The Bill of Rights of the United States of America ensures every citizen of our nation the freedoms not explicitly indicated in the Constitution, such as freedom of religion, freedom of speech, the right a free press, the right to assemble freely without persecution, the right to keep and bear arms, it affords us the freedom from unreasonable search and seizure, security in personal effects, and freedom from warrants issued without probable cause, indictment by a grand jury for any capital or "infamous crime", it guarantees us of a speedy trial, it guarantees all citizens a public trial with an impartial jury, and the prohibition of double jeopardy.



- **Statutory law** is the written *law* set down by a legislature or other official governing bodies.



- **Common Law** (*Case Law*) is the body of *law* developed from judicial decisions based on custom and precedent throughout the years.



- **Civil law** (Roman Law) is the body of *laws* of a state or nation regulating ordinary private matters. It governs over private disputes between citizens.



- **Criminal Law** is the body of law that governs over criminal acts. It regulates social conduct and is the laws that deal with anything that is threatening, harmful, or otherwise endangering to the property, health, safety, and moral welfare of its citizens. It also includes the punishment of people who violate these laws.



- **Equity Law** (Chancery) the application conscience or the principles of natural justice to the settlement of controversies. In other words it means to provide fairness and impartiality in the matters of common law.



- **Administrative law** is the body of law that governs the activities of the administrative agencies of government. Their actions can include rulemaking, adjudication, or the enforcement of a specific regulatory agenda.

The Evidence in Court

Since the accused is innocent until proven guilty, it is important for the forensic crime scene team to understand the evidence and how its significance is perceived in the courts. One of the issues of evidence as it is being introduced

in the court is its probative value. In other words does the evidence being presented prove something towards the case?

There are many types of evidence that can be used by the prosecution or the defense to prove their case.

Direct Evidence

Is evidence that establishes a fact through eyewitness testimony or victim's testimony. It can also be derived by the confession of a suspect. It also pertains to any evidence that is found on the person. Direct Evidence can also come from any audio or visual recording of the act or crime.

Indirect Evidence

All physical evidence is considered circumstantial evidence, which requires that a judge and/or jury make inferences about what transpired at the scene of a crime. It is important to note that physical evidence is nearly always circumstantial. Therefore evidence analyzed forensically is mostly circumstantial evidence.

Direct versus Indirect evidence

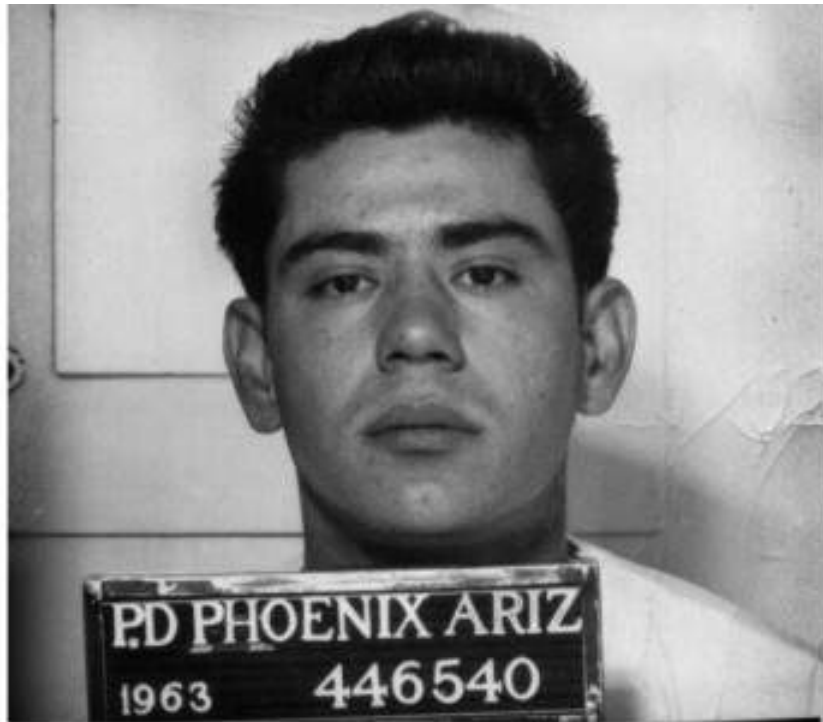
Physical evidence can be proven significant to a case or not, whereas direct evidence is more subjective due to its nature. For example eyewitnesses can be subjective and add their own perspective when identifying perpetrators or remembering certain events. When questioning the suspect or victim detectives may use questionable techniques, which can lead to erroneous testimony and confessions. Also time can be subjective, for example the maturity of the eyewitness and or the passing of time since the crime can also lead to faulty testimony. When dealing with indirect evidence, the forensic scientist is impartial and does not rely on witness testimonial, instead the scientist relies on the scientific method to analyze the evidence and determine its significance to the case. If anything direct evidence if linked to the circumstantial evidence, can be used to corroborate and strengthen the probative value of the physical evidence.



Evidence Admissibility in a Court of Law

The admissibility of evidence is not only predicated by the Constitution of the U.S., but also precedents that determine the admissibility of scientific results and how those results are explained in court

- In the case **Frye v. United States** (1923) the admissibility of the polygraph test as evidence was in issue. The court held that expert testimony must be based on scientific methods that are sufficiently established and accepted as a result the Frye standard was established. It provides that expert testimony on a scientific technique is only admissible when that technique is accepted as reliable within the scientific community.
- **Daubert v. Merrell Dow Pharmaceuticals** (1993) is a Supreme Court case which set the standard for admitting expert testimony in federal court. The court decided that the Federal Rules of Evidence took precedence over the Frye standard. The Federal Rules of Evidence require the Judge who is overseeing the case to act as the final say when it comes to admitting scientific testimony, therefore determining whether or not the testimony or evidence is scientifically valid and relevant to the case being heard.



- **Miranda v Arizona**, in 1963, Ernesto Miranda, a 23 year old mentally disturbed man, was accused of kidnapping and raping an 18-year-old woman in Phoenix, Arizona. He was brought in for questioning, and confessed to the crime. He was not told that he did not have to speak or that he could have a lawyer present. At trial, Miranda's lawyer tried to get the confession thrown out, but the motion was denied. The case went to the Supreme Court in 1966. The Court ruled that the statements made to the police could not be used as evidence, since Mr. Miranda had not been advised of his rights.



Miranda Rights

You have the right to remain silent. Anything you say can and will be used against you in a court of law. You have the right to speak to an attorney, and to have an attorney present during any questioning. If you cannot afford a lawyer, one will be provided for you at the government's expense.

Admissibility is determined by:

- Whether the theory or technique can be tested
- Whether the science has been offered for peer review
- Whether the rate of error is acceptable
- Whether the method at issue enjoys widespread acceptance.
- Whether the opinion is relevant to the issue
- The judge decides if the evidence can be entered into the trial.

Rules of Evidence Admissibility

In order for evidence to be admissible, it must be:

- Probative—actually prove something
- Material—address an issue that is relevant to the particular crime



Types of Crimes

- An **Infraction** (sometimes called violations) are petty offenses that are typically punishable by fines, but not jail time.
- A **Misdemeanor** is considered criminal offenses that carry up to a year in jail in most states. Punishment can also include payment of a fine, probation, community service, and or restitution.
- **Felonies** are the most serious type of criminal offense. They often involve serious physical harm or threat of harm, can also include white collar crimes and fraud. Felonies carry potential imprisonment from a range of one year to life imprisonment.



Facets of Guilt

Try to prove:

- Means—person had the ability to do the crime.
- Motive—person had a reason to do the crime (not necessary to prove in a court of law).
- Opportunity—person can be placed at the crime

Conclusion:

In conclusion the forensic scientist has two sets of ethical standards to abide by; scientific and legal ethical standards. Therefore when analyzing a crime scene it is important to keep in mind not only the scientific procedures that go into any experimentation, but also to be mindful of the legal procedures and chain of custody that must be adhered to in order for the evidence to be admissible in a court of law. The forensic scientist's duties are not only confined to gathering evidence at the crime scene and examining, testing, and analyzing the data in their lab, but also the courtroom where they may be asked to testify about the results of the data that was gathered from the evidence found at the crime scene.

Videos:

Law 101: Legal Guide for the Forensic Expert

https://www.youtube.com/watch?v=HyO5ke2eMCI&feature=player_detailpage

Naked Science - Forensics Under Fire (Full Documentary)

https://www.youtube.com/watch?feature=player_detailpage&v=dSARvR1SnH4

Basics of Law/Value of Evidence Review Questions

True or False

1. Because science deals with natural phenomena, forensic scientists do not have to comply with legal requirements.
2. One of the basic functions of a forensic scientist is to provide important evidence for the prosecution.

Fill in the blanks

3. _____ is the application of science to the criminal and civil laws that are enforced by police agencies in a criminal justice system.
4. Is any object that can establish that a crime has been committed, or can link a crime and its victim or its perpetrator.
5. Processing physical evidence includes recognizing, preserving, and _____ that evidence.

Short Answers

6. List three main functions of a forensic scientist.
7. What is the difference between the criminology and criminalistics?
8. What is the definition of a forensic scientist?
9. What is admissible evidence?
10. What is the significance of Daubert vs Merrell Dow? When did it occur?
11. What are the Miranda Rights?
12. In what instance is evidence admissible in court?
13. How is an 'expert' determined? Who determines one?
14. How do scientists solve problems?
15. What is a differences between criminal and civil law?
16. What are the U.S. Bill of Rights?

Basics of Law/Value of Evidence Answer Key

True or False

- 1) False
- 2) False

Fill in the blank

- 3) Forensic science
- 4) Physical evidence
- 5) Analyzing

Short Answers

Answers may be subjective

CONCEPT

4

Unit 4 Collection of Evidence & Crime Scene Investigation

TEKS

Identify roles, functions, and responsibilities of forensic science professionals. [4B]

Summarize the ethical standards required of a forensic science professional. [4C]

Recognize the major contributors to the development of forensic science. [4E]

Analyze the role of scientists such as forensic pathologists and anthropologists as they relate to a homicide investigation. [5A]

Demonstrate the ability to work as a member of a team. [5B]

Conduct a systematic search of a simulated crime scene for physical evidence following crime scene protocol. [5C]

Apply knowledge of the elements of criminal law that guide search and seizure of persons, property, and evidence. [5D]

Describe the elements of a crime scene sketch such as measurements, compass directions, scale of proportion, legend, key, and title. [5E]

Develop a crime scene sketch using triangulation, rectangular coordinates, straight-line methods, and use of coordinates on transecting baseline. [5F]

Outline the chain of custody procedure for evidence discovered in a crime scene. [5G]

Demonstrate proper techniques for collecting and packaging physical evidence found at a crime scene. [5H]

Explain the functions of national databases available to forensic scientists. [5I]

Collect and preserve physical evidence from a simulated crime scene. [5J]

Demonstrate conversions of measurements between English and International System (SI) of units. [6A]

Distinguish between physical and chemical properties of matter using the periodic table. [6B]

Identify the light sources used in forensic science such as ultraviolet light. [6G]

Process trace evidence such as soil, grass, glass, blood, fibers, and hair collected in a simulated crime scene. [7B]

To a forensic science team, the task of a crime scene investigation is to recover physical evidence and document all the information related to the crime scene processing. Once the evidence has been processed and the data has been verified, the crime scene technician is able to test investigative theories and corroborate testimonial evidence in court based on the evidence gathered from the crime scene. Evidence can be defined as anything that can prove or disprove a fact. There are two type of evidence used in the legal system; Testimonial and Physical. Testimonial evidence is information obtained through statements given by the suspect(s), victim(s), and or witnesses. Physical evidence pertains to the broad category of material objects found throughout the crime scene.

The student will be able to:

- Identify, describe the duties that pertain to each member of a forensic crime scene team.
- Implement first responder protocol and perform a systematic search of a mock crime scene.
- Document the mock crime scene and develop a rough and final crime scene sketch.
- Demonstrate proper techniques while collecting and packaging evidence at the mock crime scene.



Collection of Evidence at a Crime Scene

Locard's Exchange Principle:

Locard's exchange principle states that the perpetrator of a crime will bring something into the crime scene and leave with something from it, and that both can be used as forensic evidence. Dr. Edmond Locard formulated the basic principle of forensic science as: "Every contact leaves a trace."

Trace Evidence:

It is evidence that can be referred to as minute pieces left at a crime scene by a perpetrator or victim that can be used to identify the perpetrator or link the victim to the crime scene. Trace evidence was pioneered by Dr. Edmond Locard.

Types of Evidence: Direct (Testimonial) and Indirect (Circumstantial)

Testimonial evidence is a statement made under oath; also known as direct evidence. The Reliability of an eyewitness is paramount in an Investigation. Factors that can Influence an eyewitness include the nature of the offense and the situation in which the crime is observed, characteristics or behavior of the eyewitness at the time of the report, the manner in which the information was retrieved, the witnesses prior relationship with the accused if any, length of time between the offense and the identification.

Circumstantial Evidence relies on an inference to connect it to a conclusion of fact—like a drop of blood left at a crime scene. Physical evidence is a type of circumstantial evidence that involves objects found at a crime scene that can be introduced in a trial so as to help either the prosecution and or the defense prove their case to a jury. Physical evidence is contingent until it can be linked to the crime. It can be any object or material that is relevant in a crime; for example hair, fiber, fingerprints, documents, blood, soil, drugs, tool marks, impressions, glass.

Physical Evidence is generally more reliable than testimonial and can refute or corroborate a witness's testimony. It can also prove that a crime has been committed and link a suspect with a victim or with a crime scene. Physical evidence is also used by forensic investigators to help reconstruct the crime scene.

Reconstruction of the Crime Scene

Referring to the process of determining the sequence of events about what happened during and after a crime. Forensic reconstructions use both scientific fact gathering as well as a logical evaluation process to determine the

events that led to the crime and what evidence can be used to link a perpetrator and in some instances a victim to the crime. The Physical evidence found at the crime scene is used to answer questions about what took place, how the victim was killed, number of people involved, and the sequence of events. It is important to note that a forensic scientist will compare the questioned or unknown sample with a sample of known origin.

Types of Physical Evidence



Transient Evidence: is evidence that may degrade or disappear within a particular time frame or depending on other environmental factors. For example types of odors (putrefaction, perfume, gasoline, urine, burning, explosives, cigarette or cigar smoke), the temperature at the crime scene (surroundings, car hood, coffee, water in a bathtub, cadaver), and the imprints, indentations, and markings found at the crime scene (footprints, teeth marks in perishable foods, tire marks on certain surfaces).



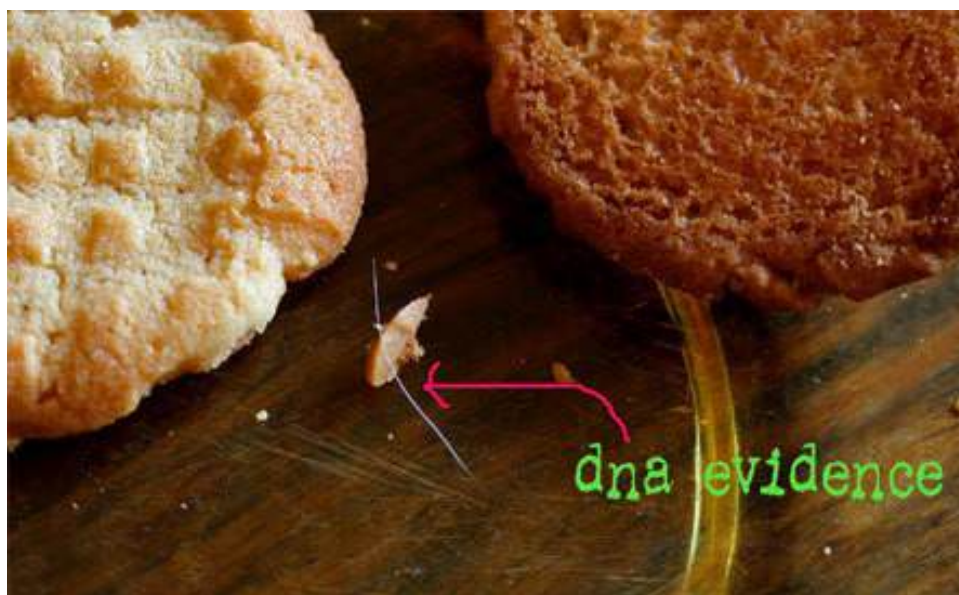
Pattern and Impression Evidence: is produced by direct contact between a person and or an object or between two objects. This type of evidence come in the form of imprints, indentations, striations, markings, fractures or deposits.



Conditional Evidence: is evidence produced by a specific event or action. This type of evidence is essential in a crime scene reconstruction and in determining the sequence of events that led to the crime. For example, light (headlight, lighting conditions), smoke (color, direction of travel, density, odor), fire (color and direction of the flames, speed of spread, temperature and condition of fire), location of injuries or wounds, of bloodstains, of the victim's vehicle, of weapons or cartridge cases, of broken glass, vehicles (doors locked or unlocked, windows opened or closed, radio off or on (station), odometer mileage), body (position, types of wounds; rigor, livor and algor mortis), and the environment of the crime scene (condition of furniture, doors and windows, any disturbance or signs of a struggle).



Transfer Evidence: This type of evidence refers to the transfer of material from one person to another and or the transfer of material from a victim or perpetrator to a crime scene.



Associative Evidence: Any type of evidence that can link an individual to a crime scene. For example bodily fluid, hair, nails, etc.

Classifying Physical Evidence



Biological: Any evidence found at a crime scene that is biotic in nature; for example blood, semen, saliva, sweat, tears, hair, bone, tissues, urine, feces, animal material, insects, bacterial, fungal, and botanical.



Chemical: Any evidence found at a crime scene that is abiotic in nature for example synthetic fibers, glass, soil, gunpowder, metal, mineral, narcotics, drugs, paper, ink, cosmetics, paint, plastic, lubricants, and some types of fertilizer



Miscellaneous: Laundry marks, voice analysis, polygraph, photography, stress evaluation, psycholinguistic analysis, vehicle identification

Types of Evidence

Class: properties of evidence that can only be associated with a group and not a single source

Individual: properties of evidence that can be attributed to a common source with a high degree of certainty.

Crime Scene Investigation

A forensic investigator must prove that a crime occurred and that the person charged with the crime was responsible for the crime. When proving that a crime has occurred an investigator will look for the primary, secondary, or multiple crime scenes if applicable. If a body is discovered, then the forensic specialists will use it to further their investigation, and finally the recruitment of suspects is necessary to further the investigative process. Some of the most notable reasons for the perpetration of a crime are for the gain of financial or material wealth, for revenge, and for the emotions of love, hate, and anger.



Crime Scene Team

The goal of the crime scene team is to aid and assist law enforcement agencies in the investigation of a crime. The major role of the team is to secure the crime scene. The team also is responsible for the documentation of the crime scene and its surroundings. The forensic team must ensure the proper methods of handling, collecting and the packaging of evidence found at the scene. The forensic specialist may also aid law enforcement personal in the reconstruction of events that led to the alleged crime. The team is comprised forensic scientists from many different disciplines as well as law enforcement personal. The first officer on the scene is responsible for following the acronym **A.D.A.P.T.** which stands for the following; **A**ssess the crime scene and assist anybody who may be hurt or in need of, **D**etain any suspect at the scene of the crime and or witness which may have seen or reported the crime, **A**rrest the perpetrator if at the scene, **P**rotect the crime scene from contamination, and **T**ake notes in order to aid in the investigation. If the victim or suspect is injured in any way the medics will be called in.

CRIME SCENE INVESTIGATION

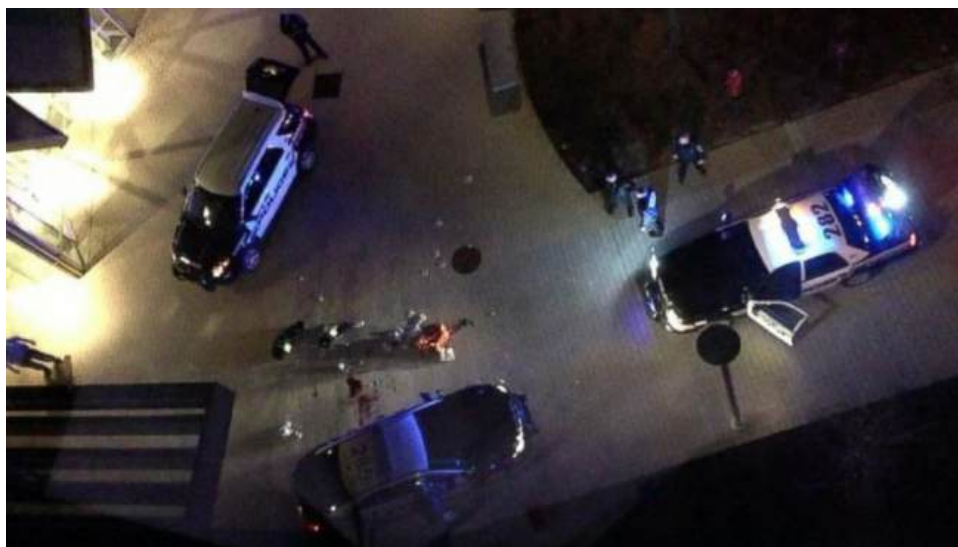
In a crime scene investigation the team has to be able to recognize, identify, individualize the evidence and finally reconstruct the crime scene. During the recognition phase, the team must survey the crime scene, document everything done at the scene, and collect all possible evidence. In the identification phase forensic specialists run comparison testing on the evidence found to relate it to the crime scene. The evaluation and interpretation of the evidence and the crime scene is done during the individualization phase. Finally, once all the evidence at the crime scene has been gathered and identified, the scene has been sketched and photographed, and the investigation has been documented; it is time to present and report the results to the responsible agency responsible for the crime scene. This final piece of the puzzle is called the reconstruction phase.



• Processing a Crime Scene

When processing a crime scene the first thing that must be done is to make sure that the first officer at the crime scene isolate and secure the scene. The next step is to document everything that is seen at the location. Once

the forensic team arrives, they will be charged with duty of searching for evidence. After the evidence has been collected, the specialists have to package the evidence in accordance to its type and make sure that the chain of custody is maintained from the crime scene to the crime lab. At the crime lab the evidence is analyzed and linked to the crime if applicable.



- **Crime Scene Survey**

When creating a survey of the crime scene, it is important to do Walk-through; this action is primarily performed by the crime scene investigator, the first officer and sometimes the lead detective. The purpose of the walk through is to get a mental picture of the scene as well as to begin a theory of events that may have conspired. Another reason is to note any transient or conditional evidence, like blood, or impressions that may be found along the way before they are lost to impending weather conditions. The walk through also gives the investigator time to record the initial observations pertaining to who, what, when, and possibly how. Finally it is vital to the investigation to identify the special needs within the crime scene. For example, a forensic anthropologist or arson specialist. The crime scene team has to be notified of any precautions needed to be taken before entering the crime scene as well as equipment they need to bring along. Finally the walk through allows the investigator to make the necessary calls to notify any other agency that may need to be involved in the crime scene investigation.

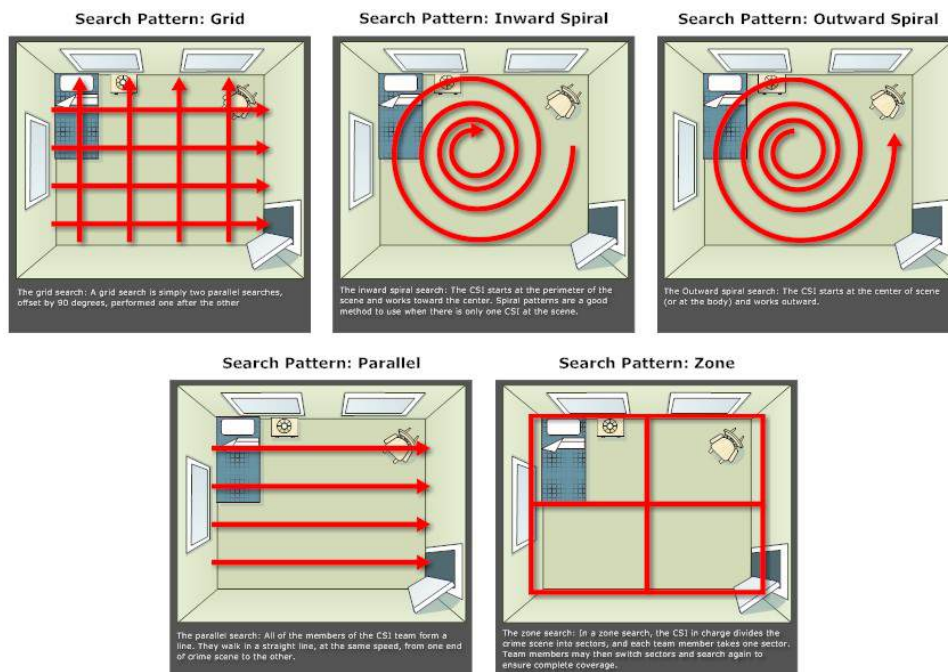


- **Documentation**

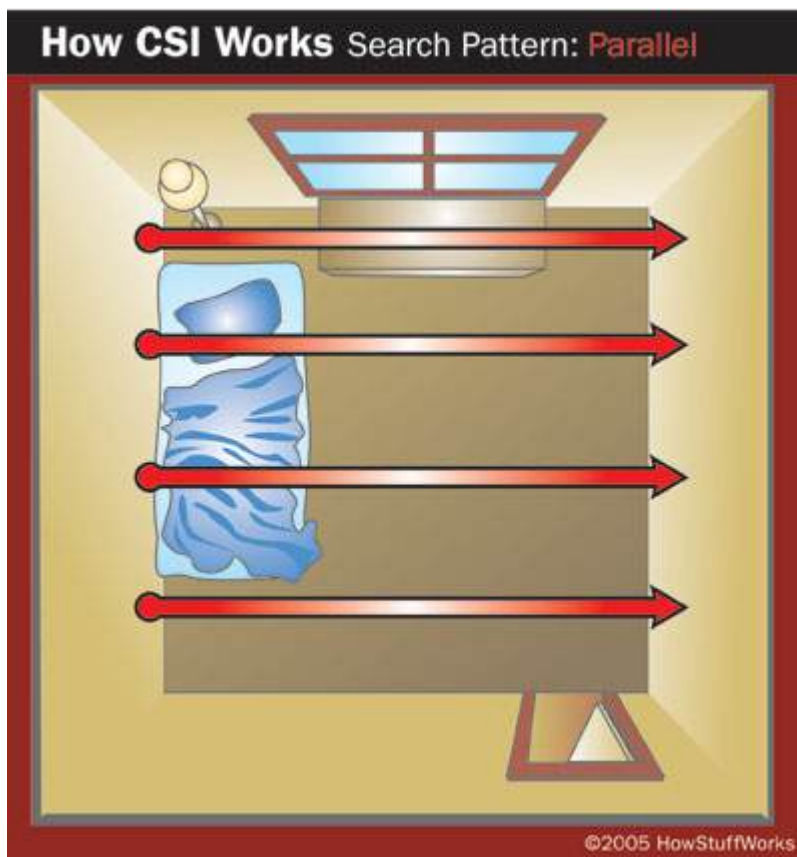
When documenting a crime scene it is necessary to take detailed **notes** that have the date and time, a detailed description of the location and the environment around it. It is also noteworthy to describe the weather and its effect to the scene if any. A precise description of the crime with location points of potential evidence relative. Make sure to take down the names of all people involved.

Another important tool in documenting a crime scene is to employ the use of **photography**. Photos will be taken of the crime scene and its surrounding environment. The photos will be taken at different angles and ranges to give the investigators different points of view. **Sketches** are used to document the entire crime scene by drawing the scene and including the following, the date, time, scale, reference points, distance measurements, names of investigators, victims, suspects, and a legend (key). A **video** of the crime scene can also be used as a type of documentation which can allow narration in its footage.

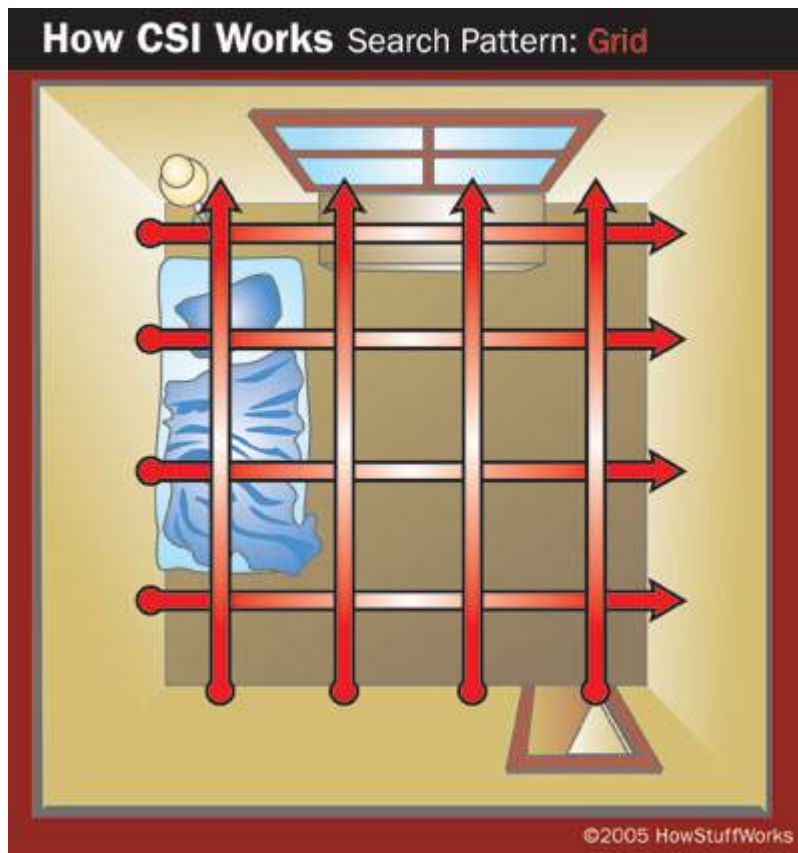
How CSI Works: Search Patterns



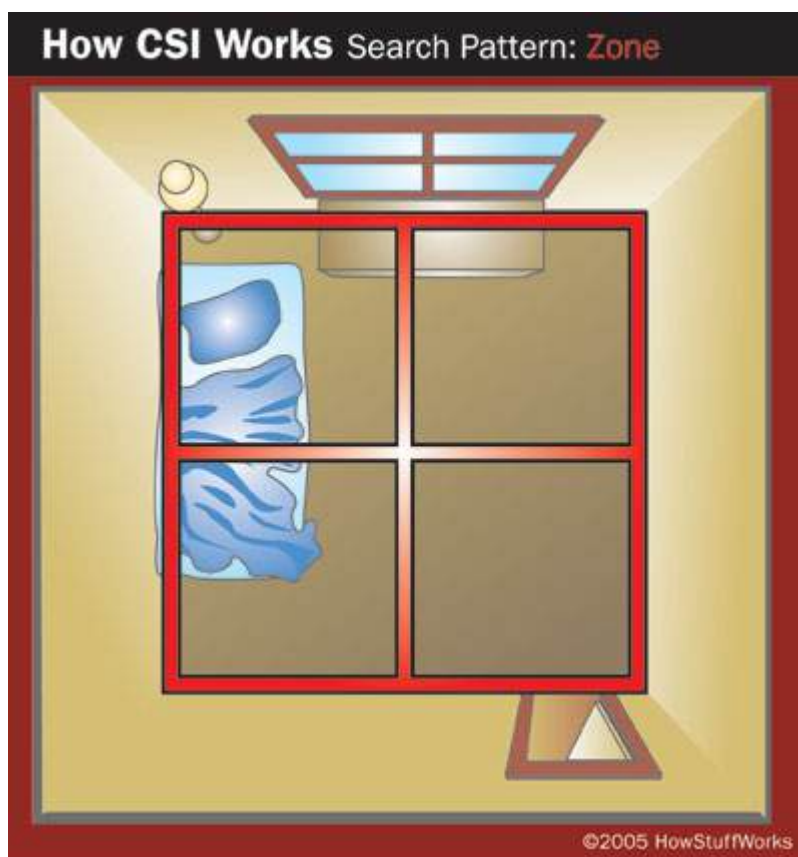
Search Methods



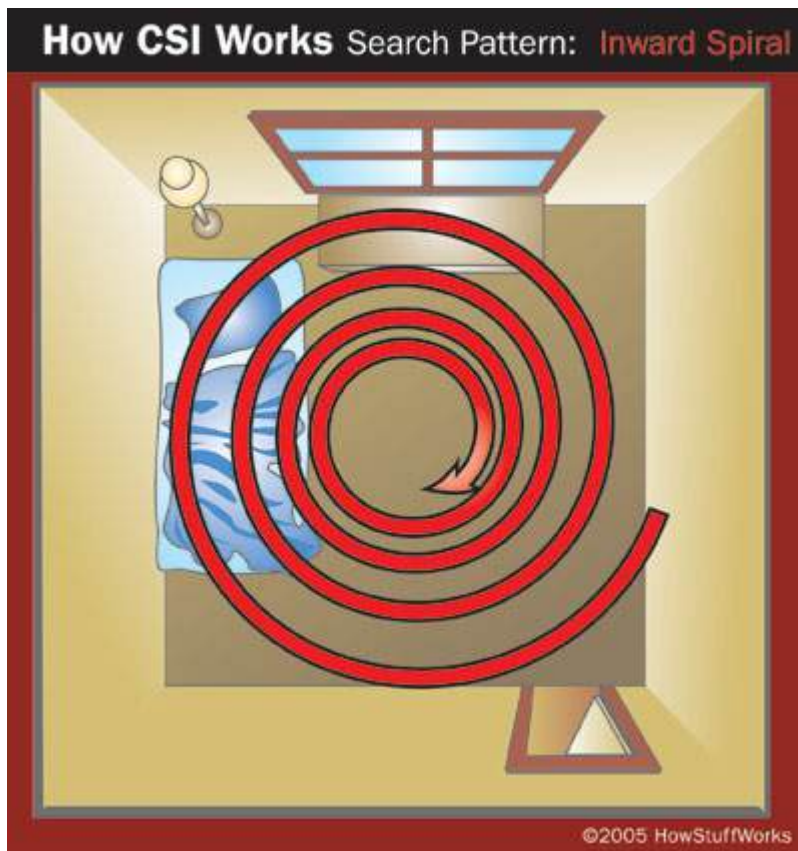
- Line or Parallel method



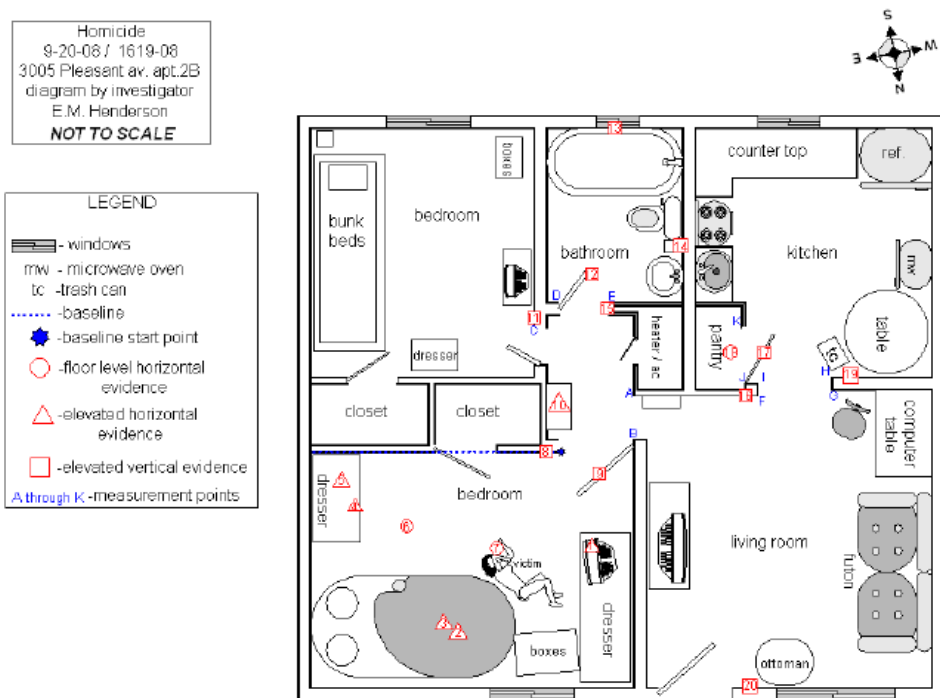
- **Grid method:** It is a double-line search



- **Zone method:** Effective in houses or buildings; teams members are assigned small zones for searching.



- **Spiral method:** may move inward or outward; best used where there are no physical barriers



- **Crime Scene Sketch**

Processing Evidence at a Crime Scene

Within the Forensic team it is the responsibility of the evidence collector to ensure that the evidence is collected, packaged, marked, sealed, and preserved in a consistent manner. To make certain that the evidence is not contaminated each item must be placed in a separate container, sealed, and labeled. Depending on the nature and frailty of the evidence, there are different types of specific or special collection and packaging techniques to be employed.



- **Collect and Package Physical Evidence**

When collecting evidence it is imperative to take the necessary precautions to ensure that there is no contamination of the evidence. For example when searching through a crime scene following must be worn by the evidence collection personal, disposable gloves, a splash proof mask or goggles, coveralls with a hood, and slippers. When working with blood soaked clothing the evidence must be air-dried and individually stored in paper bags.

During an arson investigation all charred clothing or debris has be stored in air-tight containers so that evaporation of volatile petroleum residues does not occur.

CHAIN OF CUSTODY

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 Received By: _____
 Date: _____ Time: _____ am/pm

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 Date: _____ Time: _____ am/pm

K12 FORENSICS
 3000 N. 10th St., Suite 100, Phoenix, AZ 85016
 Phone No.: 704.222.0489

-EVIDENCE-

Submitting Agency: _____
 Case No.: _____
 Item No.: _____
 Date of Collection: _____
 Time of Collection: _____
 Collector(s): _____
 Badge No.: _____
 Description of Enclosed Substanc: _____
 Location Where Collected: _____
 Type of Offense: _____
 Victim's Full Name: _____
 Suspect's Full Name: _____

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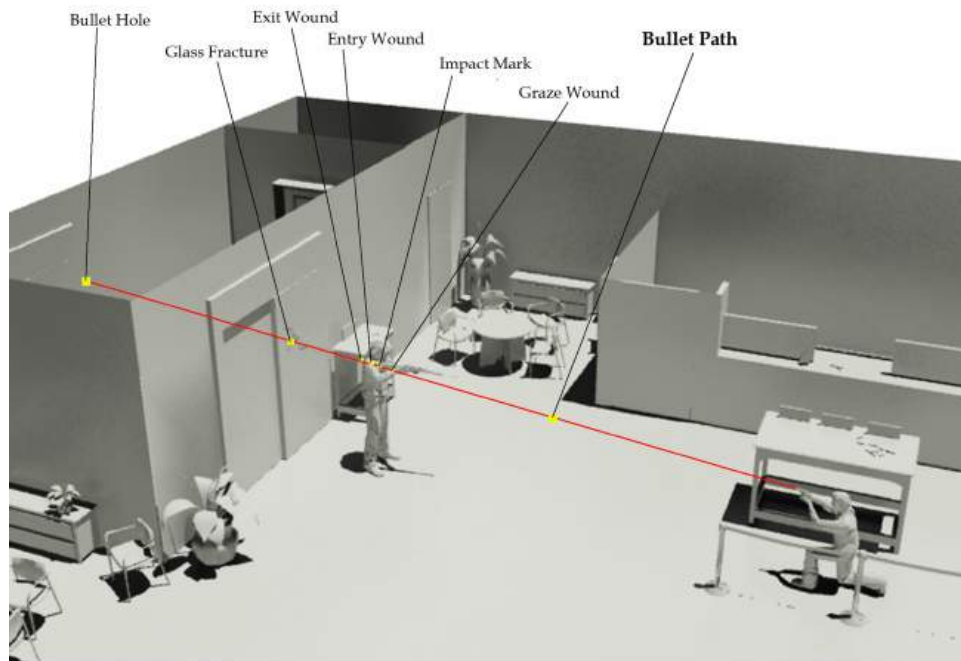
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- **Chain of Custody**

All evidence gathered at a crime scene must go through a chain of custody, where there is a written record of all the people who have had possession of the evidence from inception to the presentation of the evidence in a court of law. Therefore every person who has handled or examined the evidence is held accountable for the following duties. Keeping a written record of the date and the location at which the evidence was transferred from one professional to another. The record will also include the purpose of the transfer, for example the transfer of blood soaked clothing from the crime scene to the forensic serology lab for analysis. It is also important to note that in addition to the written chain of custody record all evidence containers and or packages must be marked for identification and be initialed by the evidence collector after it has been sealed.



- **Crime Scene Reconstruction**

After Doing their initial walk through and reviewing all their notes investigators can develop a hypothesis of what may have happened at the crime scene. The hypothesis depends on all the evidence that has been collected, examined, tested, and analyzed to determine its significance in correlation to the crime scene. If the data gathered corroborates with the hypothesis, then a theory is formulated which allows law enforcement officials to continue their investigation and present their case to prosecutors in charge of presenting the case to the court.

Conclusion

As mentioned earlier a forensic science team's main duties are to recover physical evidence document all the information related to the crime, send it all through a chain of custody to the forensic lab, where it can be examined, tested and analyzed. The team is then ready to reconstruct the crime scene and test investigative theories and corroborate testimonial evidence in court. Evidence is anything that can prove or disprove a fact. Therefore it is important for the forensic team to demonstrate proper techniques of collecting and packaging the evidence, which in turn can prove or disprove the facts in any given case.

Videos:

Processing a Crime Scene

https://www.youtube.com/watch?v=ur1GxXZGnNI&feature=player_detailpage

Crime Scene Evidence

https://www.youtube.com/watch?v=EQUE8IeVmpA&feature=player_detailpage

Unit 4 Review Questions:

Multiple Choice

1. Observing a crime scene involves what two things?
 - a) Initial walkthrough and plan of action
 - b) Walkthrough and search pattern
 - c) Collecting evidence and taking notes
 - d) Sketching the crime scene and photography

2. Who should certify that a body is “dead” at a crime scene?
 - a) First officer on scene
 - b) Medical examiner
 - c) Lead CSI investigator
 - d) Paramedic

3. The key to taking notes is what?
 - a) The legend
 - b) Scale
 - c) Shorthand
 - d) Details

4. All of the following would be considered fixed points except
 - a) Door
 - b) Wall
 - c) Desk
 - d) Window

5. The window of opportunity to collect time-sensitive information or evidence is known as
 - a) The Golden Hour
 - b) Immediate Response
 - c) Locard’s Exchange Hour
 - d) Chain of Custody

6. When packaging the evidence, you should
 - a) Package all like evidence together
 - b) Package only one piece of evidence at a time

- c) Package everything from the crime scene together
- d) Package it after you take it to the crime lab

Short Answer

- 7) What are the 5 steps of crime scene investigation?
- 8) What is the responsibility of the first officer on the scene?
- 9) When an investigator documents a crime scene, what should they include?
- 10) Describe the four search patterns that could be used to search a crime scene.

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Answer Key:

- 1. A
- 2. B
- 3. D
- 4. C
- 5. A
- 6. B
- 7. Isolate and secure the scene, document the scene, search for evidence, collect and package evidence, maintaining the chain of custody, and submit evidence for analysis.

8. A – Assess the crime scene and assist the injured D – Detain the witness A – Arrest the perpetrator P – Protect the crime scene T – Take notes

9. Notes, Photography, Sketches, and Videography

10. Spiral – may move inward or outward; best used where there are no physical barriers

Grid – basically a double-line search; effective, but time-consuming

Line (Strip) – best in large, outdoor scenes

Zone (Quadrant) – most

CONCEPT

5

Unit 5 Hair Evidence

TEKS

(8) The student recognizes the methods to process and analyze trace evidence commonly found in a crime scene. The student is expected to:

(E) describe the instrumental analysis of trace evidence such as microscopy and spectrometry;

(F) compare and contrast the microscopic characteristics of the human hair and animal hair;

(G) describe and illustrate the different microscopic characteristics used to determine the racial and somatic origin of human hair samples.

Objectives

In this chapter, topics will be explored such as:

- Hair introduction
- Structure
- Hair growth phases
- Somatic origin
- Racial origin
- Common questions and answers
- Instrumental analysis
- Evidence collection

Introduction

Hair may be valuable evidence and may show that there has been contact between a victim and suspect. The key lies in locating the evidence. If the evidence has been found, the characteristics of hair will narrow down the scope of possibilities, not only distinguishing between human and animal, but ultimately narrowing down to the race in which the hair may belong to (class evidence). Any characteristics that are common to a group are called **class evidence**. If tissue is found adhering to the hair, the identity of the individual will be revealed (individual evidence). **Individual evidence** is unique to a single person or a specific item that only one person can possess. The color, form, and structure of hair will be examined, along with DNA testing.

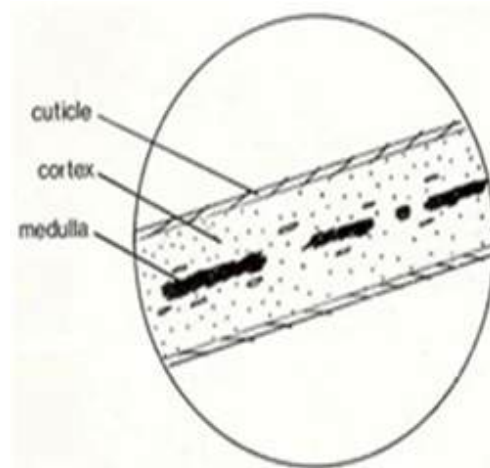
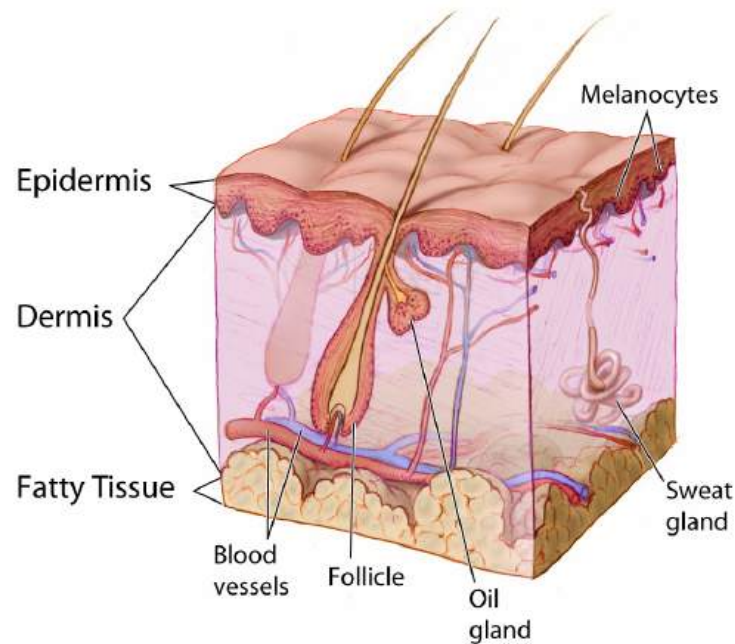
Hair Structure**MEDIA**

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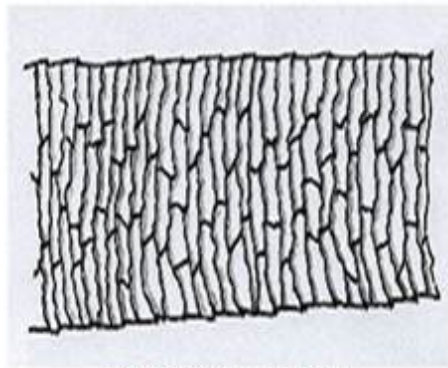
Hair is found all over mammals' bodies from the face to head to chest to extremities and pubic area. Hair grows out of the follicles beginning at the root, into the shaft and ceasing at the tip end. **Keratin** makes up a large portion of the hair shaft. It is a protein produced in the skin and allows for hair to be durable and supple. **Melanocytes** are specialized skin cells that produce a protective pigment called **melanin**. Two types of melanin, eumelanin and pheomelanin give rise to the hair color. Eumelanin produces a brown to black pigment, whereas pheomelanin produces red hair color. The hair shaft is composed of three major layers called the cuticle,

cortex, and medulla. These layers are studied closely by forensic scientists to associate an unknown hair sample (typically, head or pubic hair) at a crime scene to a suspect.

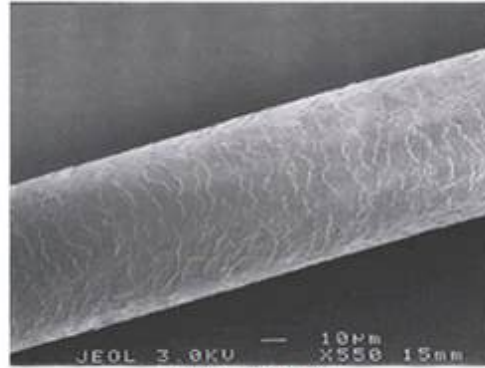


Cuticle

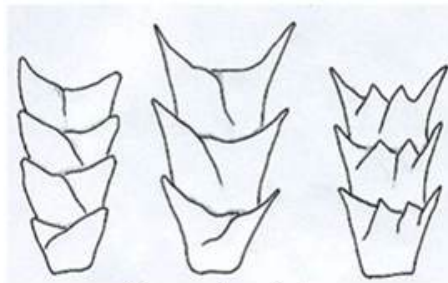
The strength of the hair is attributed to the **cuticle**, which is an outer colorless sheath of dead and keratinized cells that lie on top of one another like scales. The cuticle helps to keep the softer inner cortex from injury. There are three cuticle patterns that help aid in identification of the animal from which the hair originated. The patterns are imbricate, coronal, and spinous.



Imbricate cuticle



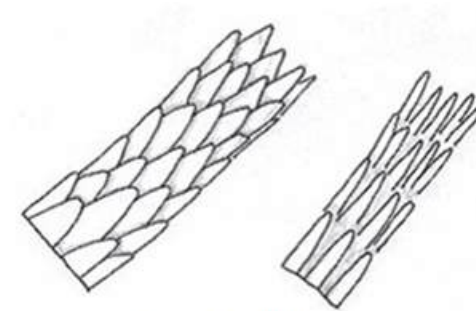
Human hair



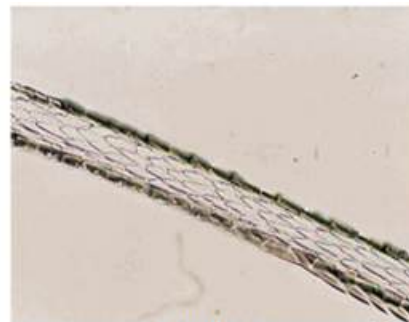
Coronal cuticle



Bat hair



Spinous cuticle



Mink hair

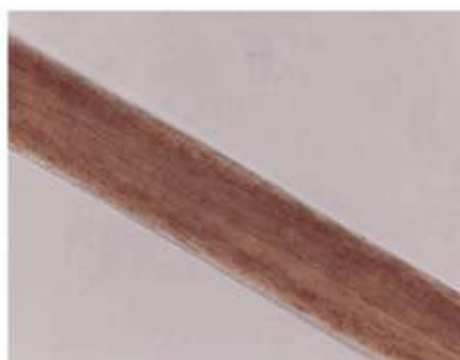
Scanning electron microscopes are used to view the hairs. The hair is gold plated and the reflection of electrons reveals the image. Cuticle casts may also be created using clear nail polish. A thin coat is placed on a glass microscope slide. The hair is positioned on the slide and allowed to dry. When it has dried, the hair is detached to expose the cuticle pattern. Studying the cuticle patterns helps to identify the species the hair may belong to. Humans, dogs, deer bear, hogs, goat, and horses possess imbricate patterns. Rabbits, seals and mink hair have spinous patterns. Bats, rats, and cats retain coronal patterns.

Cortex

The **cortex** is the layer just inside the cuticle. It is made of cortical cells and pigment granules, which give hair its characteristic color. The pigment may vary in many different ways. Colors may be light, medium, dark; or, red, brown, black, blonde, etc. The hair may be fine, moderate or large. The density of hair may be light, moderate or heavy. The distribution of the pigment granules may appear random, peripheral, even, central or one-sided. The color, shape and allocation of pigment granules provide valuable information when comparing two samples.



One-sided



Peripheral

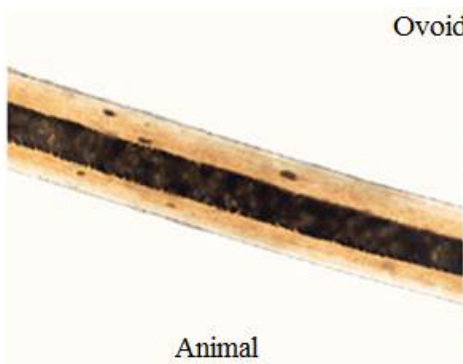


Random



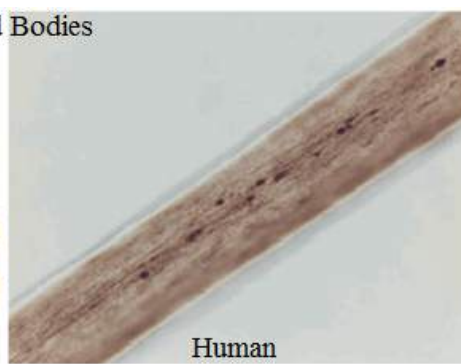
Central

The cortex may also have **ovoid bodies**, which appear to be large aggregations of pigment. Ovoid bodies could be found in both animal and human hairs, but are more prominent in animals such as dogs and cattle. **Cortical fusi** may be observed and look like small bubbles.

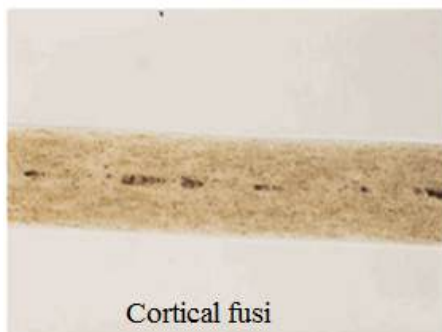


Animal

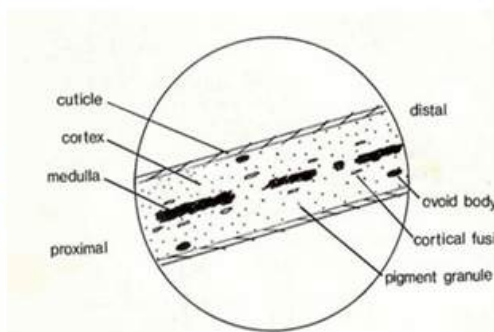
Ovoid Bodies



Human



Cortical fusi



Medulla

The **medulla** is an assembly of cells in the mid-portion of the cortex. This group of cells may or may not be present. The medulla may be classified as amorphous, patterned, or absent. If the classification is amorphous, the medulla may be further sub-classified as continuous, fragmented, or interrupted. If the medulla is patterned, it may be sub-classified as uniserial, multiserial, lattice, or vacuolated.

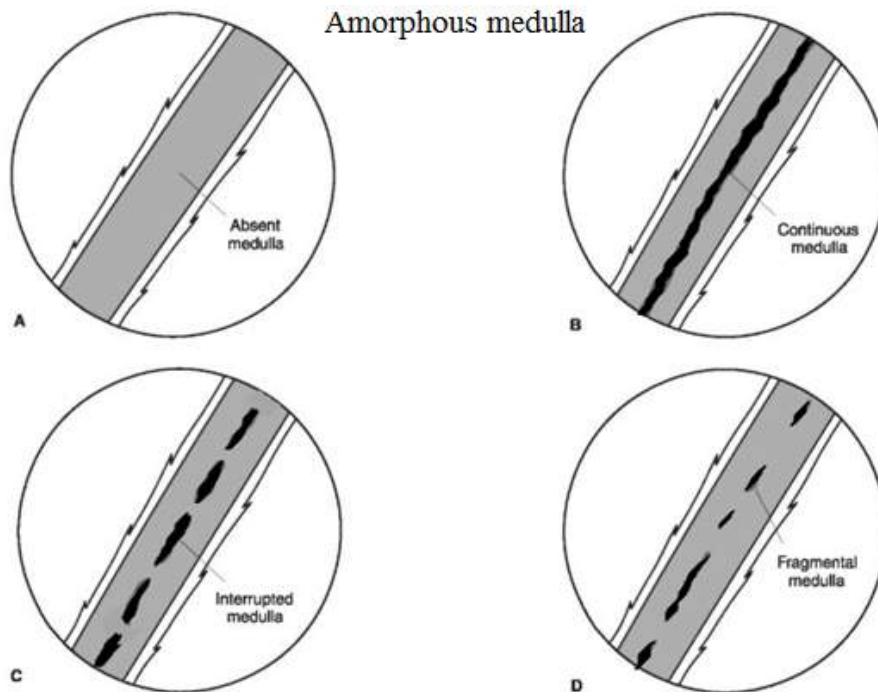
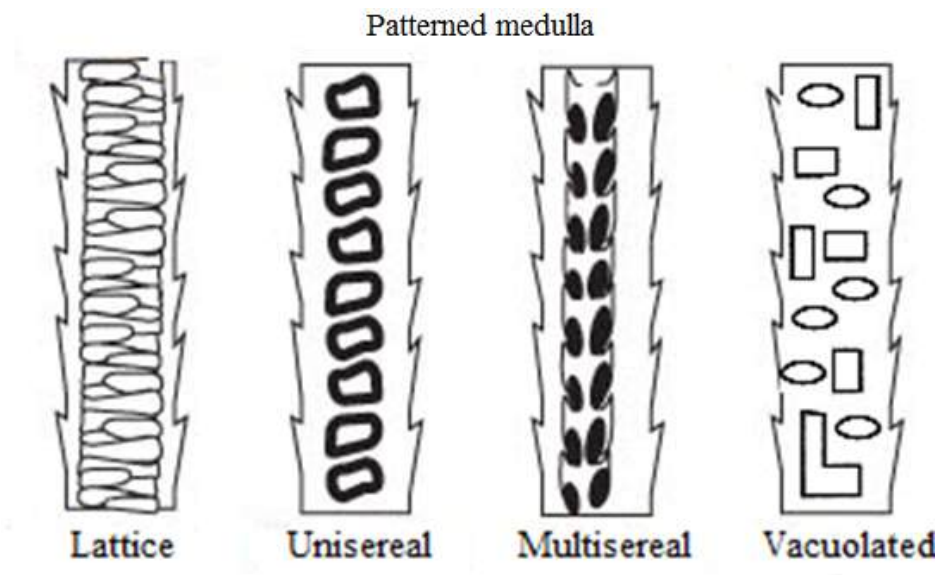
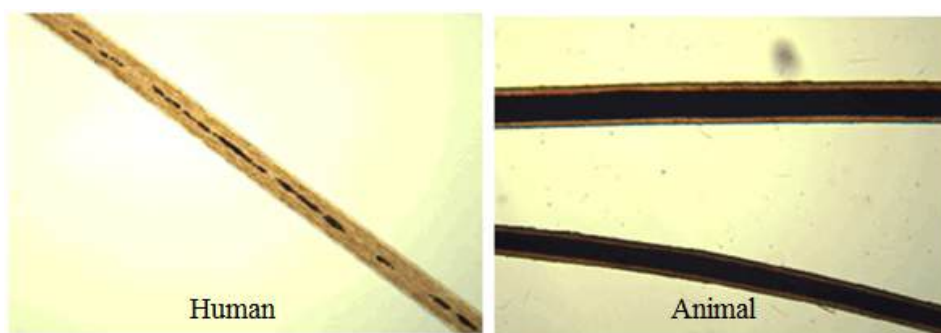


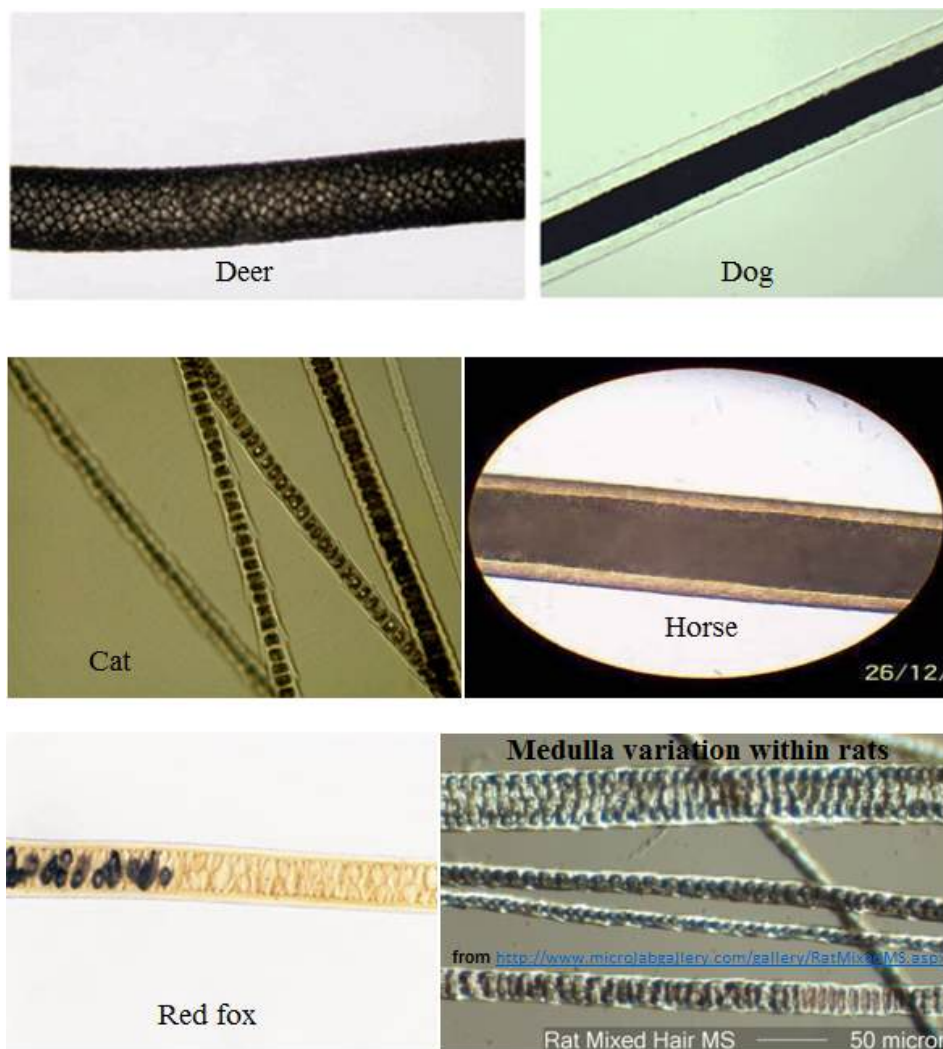
Figure 3. Light micrographs of three human hairs. The left example illustrates dark hair with a typical fragmentary medulla. The middle hair is blond and has no medulla. The right coarser hair is white with a continuous medulla.



Some medulla characteristics may suggest whether the hair sample being examined is of animal or human origin. The medullary index takes into account the diameter of the medulla versus the diameter of the shaft itself. If the diameter of the medulla takes up one-third of the shaft or less, it is of human origin. In animals, the diameter of the medulla occupies a large portion of the shaft and is one-half or greater.



Furthermore, human head hair may either have absent medulla, or amorphous medulla sub-classified as fragmented, or continuous (continuous only in people native to Asia). Animals may also have amorphous medulla, sub-classified as continuous or interrupted. Another distinguishing characteristic is that many animals have patterned medulla, which will not be found in human hair. Cats have unisereal medulla that looks like a string of pearls. Rabbits have multisereal but may also have unisereal medulla. Deer have lattice medulla that looks like fish scales. Dogs have a continuous medulla that occupies half or more of the entire shaft, as does a horse. A red fox has a random pattern, which is classified as vacuolated. Rats may vary between unisereal, multisereal, and vacuolated.

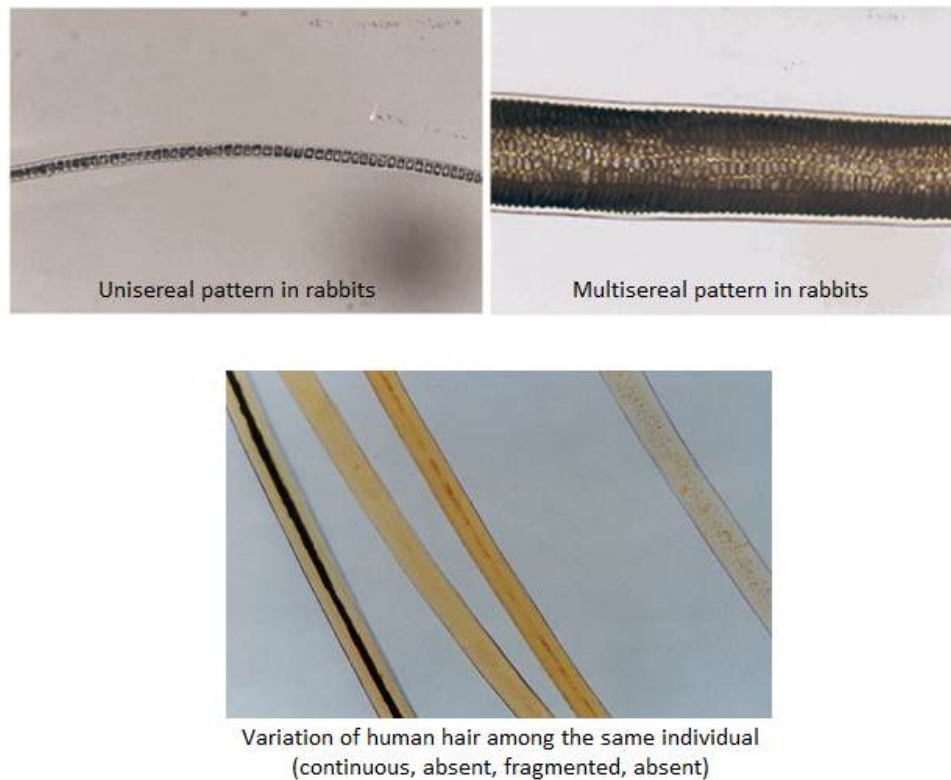


	Human Hair	Animal Hair
Cuticle	Imbricate	- Some have imbricate scales - Others exhibit coronal or spinous scales (coronal nor spinous will be found in humans)
Cortex pigment	Color and pigment remain constant throughout the shaft	Color alters drastically
Medulla	- Thin, taking up no more than 1/3 of the hair shaft diameter - Amorphous medulla (continuous if of Asian ancestry, or fragmented)	- Very wide, taking up 1/2 or more of the shaft diameter - May have amorphous medulla (continuous or interrupted) - Others have patterned medulla (uniserial, multiserial, lattice, vacuolated)

Hair not only varies from person to person, but may also be diverse within the same organism. Although the patterns mentioned above may be common amongst those species of animals, it does not mean that all hair strands will be exactly the same within that same organism. There may be slight differences. For example, in rabbits, it is common to see some hair strands that have uniserial patterns and others progress to have multiserial patterns.

Even in humans, some hair strands may have continuous medulla, and other strands analyzed may be fragmented medulla along with absent. Color may also greatly vary among the same individual, especially when a person has

died or bleached their hair. Matching color, diameter, length, medulla, and cortex pigment granules are extremely important in verifying a match between an unknown sample and a suspect. Even then, a DNA test must be performed to truly specify if it belongs to one person versus another. For that reason, when collecting hair samples for analysis, it is important to collect 25-50 strands from all/random areas of the head. This will provide a good representation of all the variations within that individual.



Tip End

Variation may be present at the tip end, leading to characteristics that may aid in tying a suspect to an unknown hair sample. Hair that has been recently cut by shears will have a rectangular end. Abraded hair will show that it has been worn away. Some modern hairstyles use razors to create a more layered look, which leaves the hair looking as if it is tapering off. Hair will typically begin to round approximately two weeks from the time that it was last cut. Broken hair may be simply snapped by the hand, or may show that there has been other physical damage. Hair can be charred by being singed or scorched by styling instrumentation. At times, the tip may be mistaken for the root because the burnt keratin forms an area that contains air bubbles at the tip, making it appear thicker than usual. Split ends can be caused by constant chemical treatments, using heated appliances, inexpensive shampoos with harsh ingredients, excess brushing, or genetic problems such as Trichorrhexis nodosa.



Hair growth phases /Root



MEDIA

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The hair root grows in three stages called the anagen, catagen, and telogen phases. During active growth, hair is attached to the follicle and is provided with nutrients by the blood vessels in the dermal papilla. While the root is attached, the hair is undergoing continuous growth and can last for a period of two up to six years and may grow roughly 1 cm every month. The root appears to be flame-shaped and is known as the **anagen** phase. Some people may have long active periods of growth that allow them to grow longer hair, whereas other people may experience hurdles growing hair past a certain length because they have shorter periods of active growth. 80-90% of scalp hair will be in the anagen phase at all times. When hair has been pulled from the follicle, a **follicular tag** may be bound to the root. This will have tissue from the follicle still attached at the root, and is an extraordinary sample for individualization.



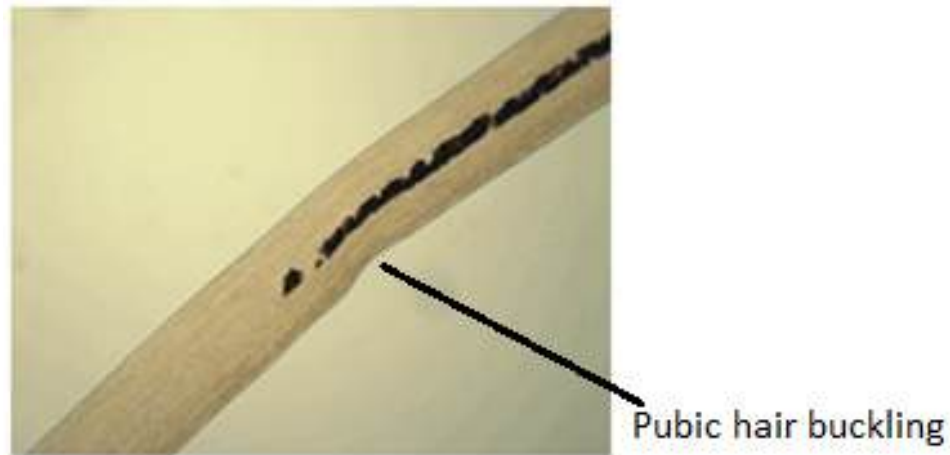
Hair grows at a much slower rate during the transitional **catagen** phase and may last two to three weeks. Roughly 3% of hair is in this phase. The root will change from being flame-shaped in the anagen phase to elongated in the catagen phase. The remainder of hair will be in the **telogen**, or resting phase. The root will appear club-shaped and will eventually be shed over a span of about two to six months. 25 to 100 telogen hairs are shed daily. Hair at this phase will typically be devoid of any tissue, which makes it more difficult to recover any nuclear DNA.



Somatic Origin

There are certain characteristics that generally aid in identifying which body part a hair strand came from. Head hair is commonly longer than other hair, tends to stay the same diameter throughout the entire shaft, pigment is evenly distributed throughout the cortex, and clues such as chemical applications, e.g., dyes and bleaching, may lend themselves into revealing that it is truly from the scalp region. Scalp hair is also not as coarse as other bodily hair.

Pubic hair is short in comparison to scalp hair. It tends to be thicker and the diameter may change throughout the shaft. It is also extremely curly and this hair type is known to possess continuous medulla. Buckling may also be an aid in origin identification.



Beard and mustache hair are rough, rigid, and have blunt ends due to constant shaving and or trimming. When a cross section is observed microscopically, the section will appear triangular in shape. Hairs are quite wide and have continuous medulla, which very characteristically within this hair type, can double.



Extremity hair (leg and arm) is short in nature and has a semicircular shape. It can be soft and is small in diameter. This hair is exposed quite frequently; therefore, the tip ends may be abraded. The cortex pigment may appear to be grain-like.

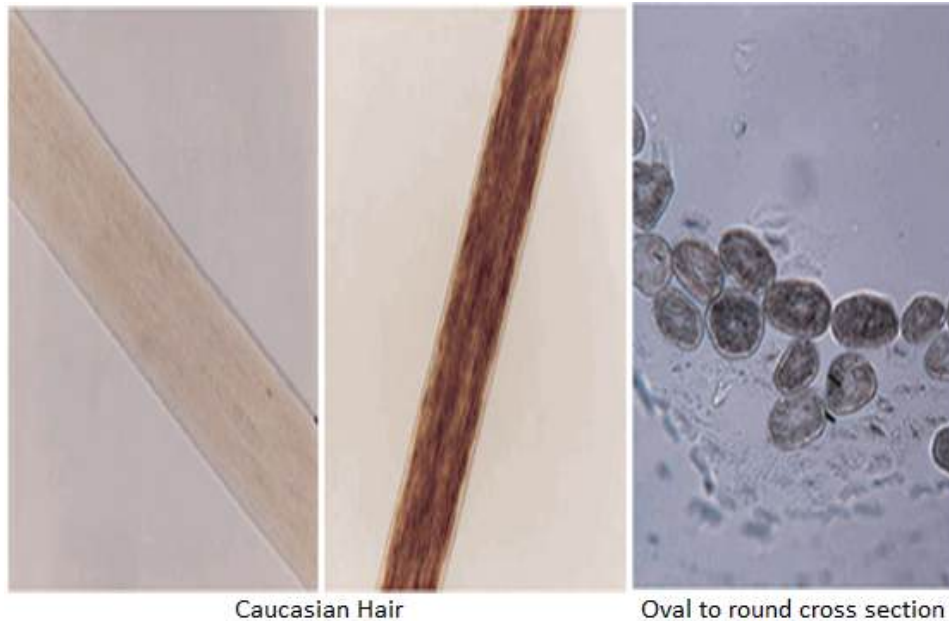
Hairs from the neck, sideburns, abdomen, upper leg, back, underarm, chest, eyebrow, eyelash, and nose are rarely compared. If these samples are found at a crime scene, they may help to contribute information during an investigation. Underarm hair is very similar to pubic hair, but the buckling will not be seen as frequently. The tips are also fine in comparison to the rest of the shaft. Chest hair has a moderate diameter and tips are darker than the rest of the shaft. They can be lengthy, are bowed, and have grainy medulla. Eyebrow and eyelash hair is short and thick.

Racial Origin

Microscopic features help to make a distinction between Caucasian, Mongoloid, and African descent. Head hairs are ideal for this type of differentiation. Mixed races might be hard to discern because their hair may have the traits of the various races they consist of.

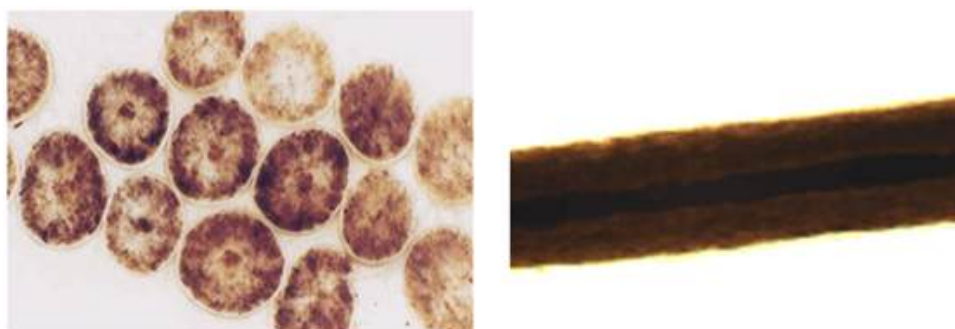
Caucasian

Caucasian hair is hair from European ancestry. These hairs show an oval to round shape in cross section. The cortex will have fine to medium pigment granules that are uniformly disseminated. The medulla may present itself as fragmented, or may be absent as well. The hair overall will be genuinely fine and can reach a medium thickness with colors that can vary from blonde to brown to red to black. Hair may typically be straight, but may present wavy characteristics.



Mongoloid

Mongoloid hair is hair from Asian ancestry. These hairs have a round cross section. The cortex has large, erratic pigment granules that are very different from those of Caucasian lineage. One feature that is distinctive within the Mongoloid race is that they have continuous medulla. The hair is fairly wide and thick and mainly presents itself as a dark brown-red to a black-red color. The strands are also very straight. One other characteristic that is unique to Asian people is that their cuticle is thicker than any other race.



African

African hair has a flat to oval cross section. The cortex has big pigment granules that are unevenly scattered. It may seem as if some of the cortex is missing color altogether, but it is just the aggregates of color that mass together in specific areas and not in other parts. The medulla may be fragmented or absent. The hair may be fine to moderate in diameter and may present a brown to black color. Strands have bends and twists and may show buckling.



Racial Origin Overview

Race	Appearance	Pigment Granules	Cross Section	Other
	Generally straight or wavy	Small and evenly distributed	Oval or round of moderate diameter with minimal variation 	Color may be blond, red, brown, or black
	Straight	Densely distributed	Round with large diameter 	Shaft tends to be coarse and straight Thick cuticle Continuous medulla
	Kinky, curly, or coiled	Densely distributed, clumped, may differ in size and shape	Flattened with moderate to small diameter and considerable variation 	

Questions and Answers

Can age be determined?

Age cannot be determined exactly, but an age range may be revealed in a couple of instances. Infant hairs are short, very fine and soft, and have faint color. They are very distinct versus hairs of other varying ages. Hairs in elderly people also become finer and they lose pigment.

May the sex be determined?

The sex may not be determined by basic microscopic examination. Some characteristics of the hair strand may hint to it being of one sex versus the other. Hair found that is long and microscopically shows that it has been dyed or bleached may show that it more than likely belongs to that of a female. If tissue is found on the root, testing for DNA will settle any debate as to which sex the hair belongs to.

Is it possible to determine how long ago a person dyed their hair?

If a sample found at a crime scene is blonde and a suspect's hair sample is brown, that would somewhat show that maybe this should not be the correct suspect to investigate. What if the suspect changed their appearance after they committed a crime to try to stay under the radar? It is certainly possible to determine when a person last dyed

their hair. Hair grows one centimeter per month. Let's say that the suspect dyed their natural blonde hair brown three months ago, roughly when the crime was committed. The time frame of this treatment can be determined by measuring the segment of growth. If it has grown three centimeters in that time period, this indicates that the hair was dyed three months ago. Now a hair expert can compare the blonde crime scene hair with the 3 cm of blonde growth on that brown strand.

Is it possible to determine if hair was forcibly removed or shed?

Hair naturally shed will have a club shaped root that usually does not have any tissue bound to it. On the other hand, forcibly removed hair will present itself as an overextended strand and may have tissue adhering to it depending on the force in which it was removed. Roots with follicular tissue present may be simply brushed out by a person, or may have been pulled. Strands with tissue that appears to have irregular margins usually indicates that it was forcibly removed. Hair that is jerked swiftly may be devoid of any tissue, and hair removed slowly will have tissue bound to the root.



Is it possible to tell if a hair came from a living versus nonliving person microscopically?

Hair from a deceased person will have a dark band that is close to the distal end. This will not be seen in hair from a living person.



Is it possible to link a strand of hair to one person?

The answer here is yes and no. Let's start with the hair root. If a hair strand is found with the root in the anagen phase, nuclear DNA may be pulled from this sample. Therefore, it can be linked to one individual. Even hair that is transitioning from the anagen to catagen phase should be adequate enough. If the root is in the telogen phase, nuclear DNA will not be found, but mitochondrial DNA will be present, which is more abundant than nuclear DNA. Mitochondrial DNA will not necessarily individualize hair, but at least it can link the hair to people that have the same mother.

Instrumental Analysis

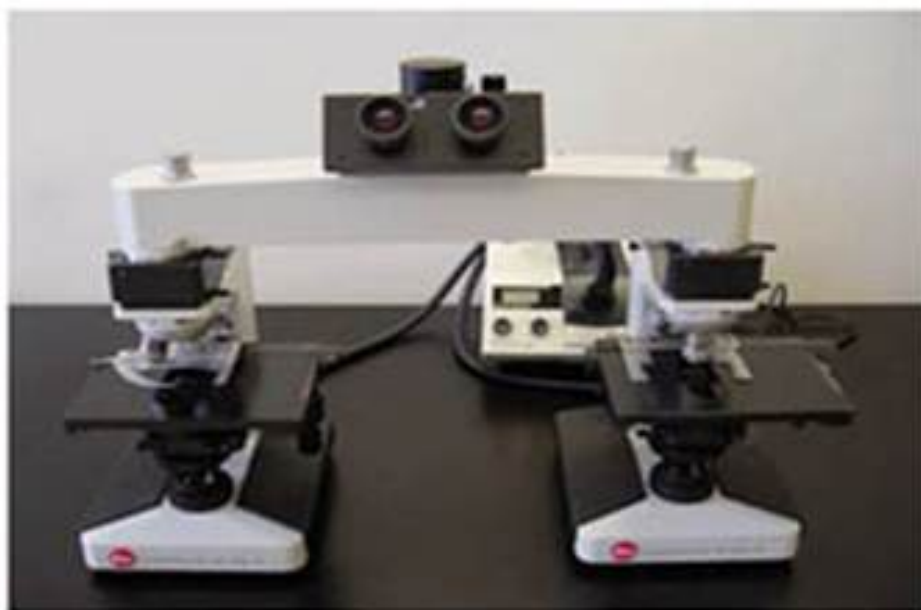


MEDIA

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Comparison microscopes are ordinarily used to view two pieces of evidence side-by-side, and may magnify the evidence up to 400x the original size. Information that may possibly be revealed by a comparison microscope examination may include human versus animal hair, race, somatic origin, and a probable match between an unknown sample and a **reference sample**. Reference samples are pieces of evidence that come from a known source, such as hair, to be compared to an unknown sample found at a crime scene. Not only are exams capable of possibly tying two pieces of evidence together, but may also exclude a sample as being similar to the one in question. Hair comparisons are somewhat questionable because the examiner may not have enough experience to deem a match. Hair DNA analysis will be the best choice when dealing with individualization.



Collection and Packaging of Evidence



MEDIA

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- Unknown hairs from the crime scene and reference samples must be sent to the lab.
- If the unknown sample is from the scalp, then 25-50 samples from random areas on the head of the suspect must be collected and submitted as well.

- If the unknown sample is pubic hair, 24 pubic hairs from the suspect must be submitted for comparison.
- When attempting to collect foreign hairs for a rape case, a comb must be used to try to collect any detached hairs.
- After the detached hairs are collected, the 24 reference samples must be pulled.
- The comb and hair are packaged separate from one another.
- Any loose hairs at a crime scene must be collected with forceps.
- Hair is to be folded in a paper (druggist fold) and then placed in an envelope to ensure that no hairs will be displaced.
- Tape lifts may also be done to ensure that no samples are left behind.
- Vacuum sweepings can be done to ensure that nothing is left behind at the crime scene.
- The whole vacuum bag will be sent to the lab for analysis.
- In any autopsy, hair samples will always be taken.



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Chapter Summary

- Hair evidence may link a victim and suspect.
- Any characteristics that are common to a group are called class evidence.
- Individual evidence is unique to a single person or a specific item that only one person can possess.
- Hair grows out of the follicles beginning at the root, into the shaft and ceasing at the tip end.
- The hair shaft is composed of three major layers called the cuticle, cortex, and medulla.
- The strength of the hair is attributed to the cuticle, which is an outer colorless sheath of dead and keratinized cells that lie on top of one another like scales.
- The cuticle patterns are imbricate, coronal, and spinous.
- Humans have imbricate cuticles while animals may have any of the three cuticle patterns.
- The cortex is the layer just inside the cuticle. It is made of cortical cells and pigment granules, which give hair its characteristic color.
- The color and pigment remain constant throughout the human hair shaft while the color alters drastically in animals.
- The medulla is an assembly of cells in the mid-portion of the cortex. This group of cells may or may not be present.
- The medulla may be classified as amorphous, patterned, or absent.
- If the classification is amorphous, the medulla may be further sub-classified as continuous, fragmented, or interrupted.

- If the medulla is patterned, it may be sub-classified as uniserial, multiserial, lattice, or vacuolated.
 - The medullary index takes into account the diameter of the medulla versus the diameter of the shaft itself.
 - If the diameter of the medulla takes up one-third of the shaft or less, it is of human origin. In animals, the diameter of the medulla occupies a large portion of the shaft and is one-half or greater.
-
- Human head hair may either have absent medulla, or amorphous medulla sub-classified as fragmented, or continuous (continuous only in people native to Asia).
 - Animals may also have amorphous medulla, sub-classified as continuous or interrupted. Another distinguishing characteristic is that many animals have patterned medulla, which will not be found in human hair.
 - Hair not only varies from person to person, but may also be diverse within the same organism.
 - Variation may be present at the tip end, leading to characteristics that may aid in tying a suspect to an unknown hair sample.
 - The hair root grows in three stages called the anagen, catagen, and telogen phases.
 - During active growth, the root is attached, and the hair is undergoing continuous growth that can last for a period of two up to six years. The root appears to be flame-shaped and is known as the anagen phase.
 - When hair has been pulled from the follicle, a follicular tag may be bound to the root. This will have tissue from the follicle still attached at the root, and is an extraordinary sample for individualization.
 - Hair grows at a much slower rate during the transitional catagen phase and may last two to three weeks. The root will be elongated in the catagen phase.
 - The remainder of hair of hair will be in the telogen, or resting phase. The root will appear club-shaped and will eventually be shed over a span of about two to six months.
 - There are certain characteristics that generally aid in identifying which body part a hair strand came from.
 - Head hair is commonly longer than other hair, tends to stay the same diameter throughout the entire shaft, pigment is evenly distributed throughout the cortex, and clues such as chemical applications, e.g., dyes and bleaching, may lend themselves into revealing that it is truly from the scalp region.
 - Pubic hair is short, thicker and the diameter may change throughout the shaft. It is also extremely curly and this hair type is known to possess continuous medulla.
 - Beard and mustache hairs are rough, rigid, have blunt ends due to constant shaving and or trimming, the cross section will appear triangular in shape, and hairs are wide and have continuous medulla that can double.
 - Extremity hair is short, has a semicircular shape, is soft and is small in diameter, the tip ends may be abraded, and the cortex pigment may appear to be grain-like.
 - Hairs from the neck, sideburns, abdomen, upper leg, back, underarm, chest, eyebrow, eyelash, and nose are rarely compared.
 - Microscopic features help to make a distinction between Caucasian, Mongoloid, and African descent.
 - Age cannot be determined exactly, but an age range may be revealed such as in infants and the elderly.
 - The sex may not be determined by basic microscopic examination. If tissue is found on the root, testing for DNA will settle any debate as to which sex the hair belongs to.
 - Hair grows one centimeter per month.
 - Hair naturally shed will have a club shaped root that usually does not have any tissue bound to it.
 - Forcibly removed hair will present itself as an overextended strand and may have tissue adhering to it depending on the force in which it was removed.
 - Hair from a deceased person will have a dark band that is close to the distal end. This will not be seen in hair from a living person.
 - If a hair strand is found with the root in the anagen phase, nuclear DNA may be pulled from this sample. Therefore, it can be linked to one individual.
 - If the root is in the telogen phase, mitochondrial DNA may be extracted and will not necessarily individualize hair, but at least it can link the hair to people that have the same mother.
 - Comparison microscopes are ordinarily used to view two pieces of evidence side-by-side, and may magnify the evidence up to 400x the original size.
 - Collecting and packaging evidence is of utmost importance when dealing with hair evidence.

Review Questions**Short Answer**

1. How can hair be classified as class evidence? How can it be classified as individual evidence?
2. May the cuticle of a hair shaft help to provide clues as to whether the hair is of animal or human origin? Explain.
3. Is it possible to make a distinction between pubic and beard hair microscopically? Explain.
4. An unknown hair sample at the crime scene and a sample taken from a suspect seem to match microscopically. Does this without a doubt mean that the suspect committed the crime?
5. Why is the cortex important in forensic analysis?

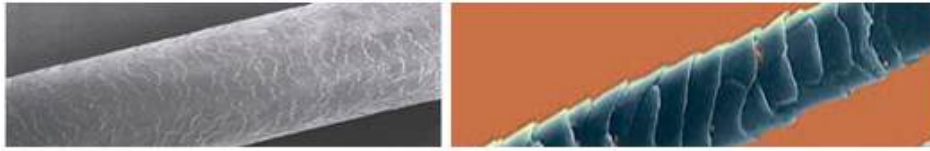
True or False

6. True or False: Leg and arm hair are short, have a semicircular shape, are soft and small in diameter, and the tip ends may be abraded. The cortex pigment may appear to be grain-like. Chest hair has a moderate diameter and tips are darker than the rest of the shaft. They can be lengthy, are bowed, and have grainy medulla.
7. True or False: The ovoid bodies within the cortex of this hair indicate that it is most likely human hair rather than animal hair.



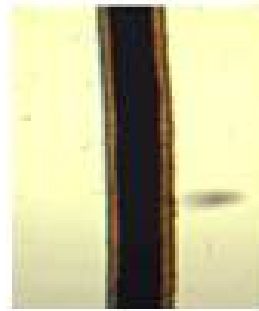
8. True or False: In order to individualize hair, DNA analysis must follow after there has been a strong structural correlation.
9. True or False: Comparison microscopes are used to view the hairs by gold plating the hair and the reflection of electrons reveals the image.
10. True or False: If scalp hairs are found at a crime scene, collecting pubic hairs for comparison will suffice.

Multiple Choice



11. The pictures shown above are either cat or dog. How can a presumptive identification be made on the species of the animal by examining the cuticle pattern?

- A. An identification cannot be made due to the fact that both the dog and cat have a coronal cuticle pattern.
- B. The cat on the left is known to have a coronal pattern while the dog on the right has an imbricate pattern.
- C. The cat on the right has a spinous pattern and the dog on the left has an imbricate pattern.
- D. The cat on the right has a coronal pattern while the dog on the left has an imbricate pattern.



12. This hair was found at a crime scene in which a male was found killed at a farm. This hair did not belong to the victim. One eyewitness did see a male Caucasian fleeing from the scene. Investigators now have to decipher whether this hair is of human or animal origin. Based on your knowledge, how would you classify this hair?

- A. This hair resembles that of a mouse since humans do not possess continuous medullation.
- B. This hair sample can be identified as from a horse since Caucasians are usually devoid of medullation.
- C. This hair is characteristic of that of a Caucasian. There is no known animal with continuous medullation
- D. The hair is characteristic of an African and does not belong to a Caucasian. Most animals possess interrupted medullation.

13. A criminalist recovered a blonde hair strand from a crime scene that is suspected to be from the culprit. The suspect provides a brown hair sample. Upon examination, the hair reveals new blonde growth from the scalp that is about 0.75 centimeters long while the remainder of the hair is dyed brown. This could help link the individual to the crime. How many weeks ago was the hair dyed?

- A. 7 weeks
- B. 4 weeks
- C. 3 weeks
- D. 1 week



14. Anagen phase: lasts up to six years; root is attached to follicle for continued growth

Catagen phase: hair continues to grow but at a slower rate which can last 2 to 3 weeks; hair is being pushed out of the follicle

Telogen phase: hair growth ends; in 2 to 6 months the hair will be pushed out

Human head hair grows in three stages. Descriptions are shown above giving the characteristics of all stages. Name the stages shown in the pictures from left to right.

- A. Telogen, catagen, anagen
- B. Anagen, telogen, catagen
- C. Catagen, anagen, telogen
- D. Anagen, catagen, telogen



15. Analyze these samples of hair and determine their race from right to left?

- A. Negroid, Caucasian, Mongoloid
- B. Mongoloid, Caucasian, Negroid
- C. Caucasian, Negroid, Mongoloid
- D. Caucasian, Mongoloid, Negroid



16. This sample was collected from a crime scene and submitted to the laboratory for analysis. Would it be possible to determine the individual's sex?

- A. Yes, mitochondrial DNA can be taken from the hair shaft to determine the sex.
- B. No, the root of the hair is missing the follicular tag.
- C. Yes, nuclear DNA from the tissue adhering to the hair will determine the sex, and may ultimately individualize the hair.
- D. Yes, the presence of dye or bleach may offer clues as to which sex the individual is.

17. CSI and police arrive at a crime scene. The police question the victim and there they learn that there were two individuals that robbed her home and one of them sexually assaulted her. The CSI unit starts to look for clues

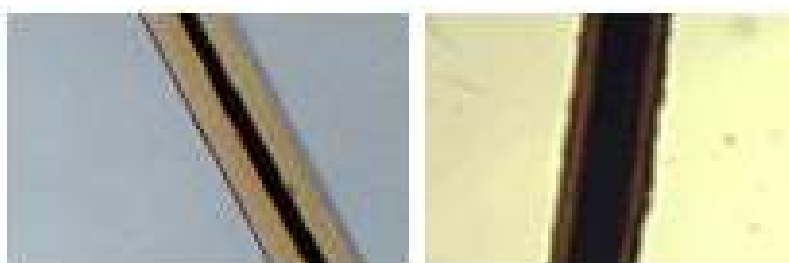
and discover one hair that does not belong to any people living at the home. At the lab, the hair is devoid of any follicular tissue and appears to have a club shape. Is it likely that they will have enough evidence to capture the duo and prove which brother committed the sex act?

- A. Due to the absence of follicular tissue, the police will not have any possible leads.
- B. Because both hairs are found to be in the catagen phase, no nuclear DNA will be found, thus they will not be able to identify the criminals.
- C. Since no nuclear DNA is present, they may analyze the mitochondrial DNA to individualize the hair.
- D. Mitochondrial DNA may be analyzed but it can't distinguish hairs from different individuals who are maternally related.



18. Which animal does this hair belong to and what type of medullary pattern does it have?

- A. This can be identified as rabbit hair because they possess uniserial patterns.
- B. This can be identified as deer hair because they possess lattice patterns.
- C. This can be identified as cat hair because they possess multiserial patterns.
- D. This can be identified as mouse hair because they possess continuous medulla.



19. Out of these two illustrations, one is horse and the other is human (not necessarily in that order). How can a presumptive identification be made on the species of the samples by examining the two pictures? Pick the best answer.

- A. Human hair has an imbricate cuticle while horse hair has a spinous cuticle.
- B. The medulla of a horse tends to be darker than that of a human.
- C. The diameter of the medulla to that of the hair shaft in humans is less than $\frac{1}{3}$, in most other animals it is $\frac{1}{2}$ or greater.
- D. The human's cortex has lighter pigment granules than the horse.

20. Study the following descriptions and specify which race the hair may have come from.

- A. fine pigment, cross section of hair is oval
- B. uneven pigment, hair is coiled
- C. cross section of hair is round, continuous medulla
- D. straight to wavy hair with even pigment

CONCEPT

6

Unit 5 Fiber Evidence

TEKS

(8) The student recognizes the methods to process and analyze trace evidence commonly found in a crime scene. The student is expected to:

(E) describe the instrumental analysis of trace evidence such as microscopy and spectrometry;

(H) differentiate between natural and synthetic fibers.

Objectives

In this chapter, a major emphasis will be placed on:

- Introduction
- Nomenclature
- Natural fibers
- Synthetic fibers
- Examination of fibers
- Magnitude of evidence
- Collection and preservation of evidence

Introduction

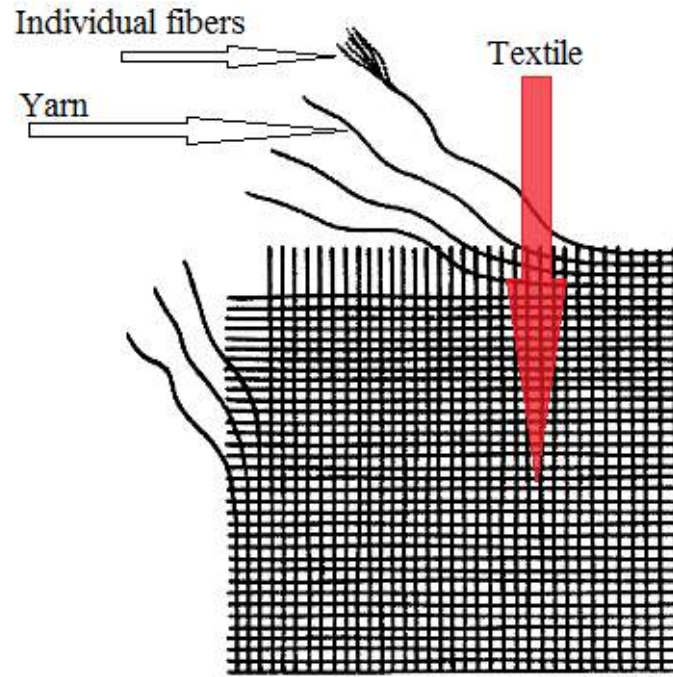
Professor E. Locard, father of Locard's Exchange Principle states, "Wherever he steps, whatever he touches, whatever he leaves, even unconsciously, will serve as a silent witness against him. Not only his fingerprints or his footprints, but his hair, the fibers from his clothes, the glass he breaks, the tool mark he leaves, the paint he scratches, the blood or semen he deposits or collects. All of these and more bear mute witness against him. This is evidence that does not forget. It is not confused by the excitement of the moment. It is not absent because human witnesses are. It is factual evidence. Physical evidence cannot be wrong, it cannot perjure itself, and it cannot be wholly absent. Only human failure to find it, study and understand it can diminish its value."

A very powerful quote expresses that no matter whether it may be a homicide, a sexual assault, or physical assault; there will always be a cross transfer between two people (victim and suspect) or an object found at the crime scene and a person. Fiber transfer may be involved in many of these instances. It may be important evidence, but the trick lies in locating it and understanding the particulars that are held within the examination.

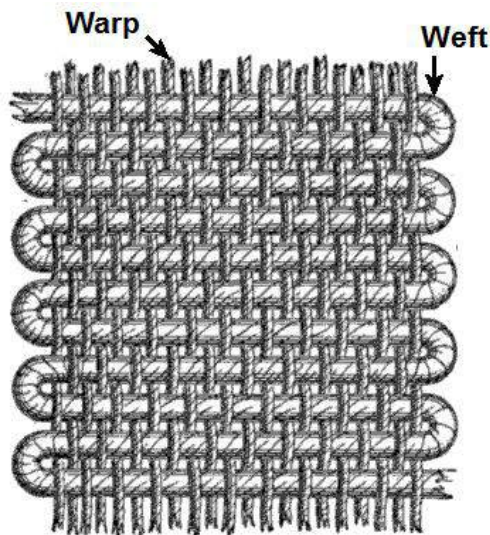
Fiber evidence is considered to be class evidence due to the high availability of garments that are made in bulk across the world. Finding these common fibers at a crime scene may not yield to be helpful in an investigation. The chance of finding something not so common may help tie a suspect to the crime scene. There are many different types of fibers that will be discussed within this chapter.

Nomenclature

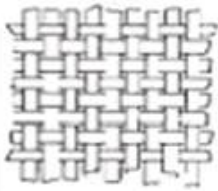
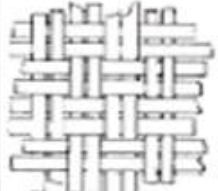
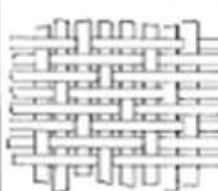
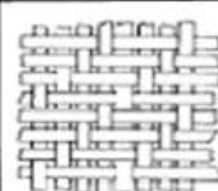
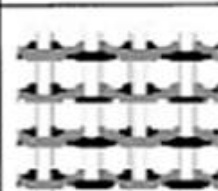
A **fiber** is a small and thin piece of string in which its length is quite bigger than the diameter. **Yarn** is a collection of fibers that are twisted together. These collections of fibers are then taken to create a **textile**, which literally becomes the fabric itself.



The pattern of the **weave** may also help to determine if a fiber came from a specific textile. A weave is generated by a lengthwise fiber being interlaced by a horizontal fiber. The lengthwise fiber is known as the **warp**, and the horizontal is known as the **weft**.

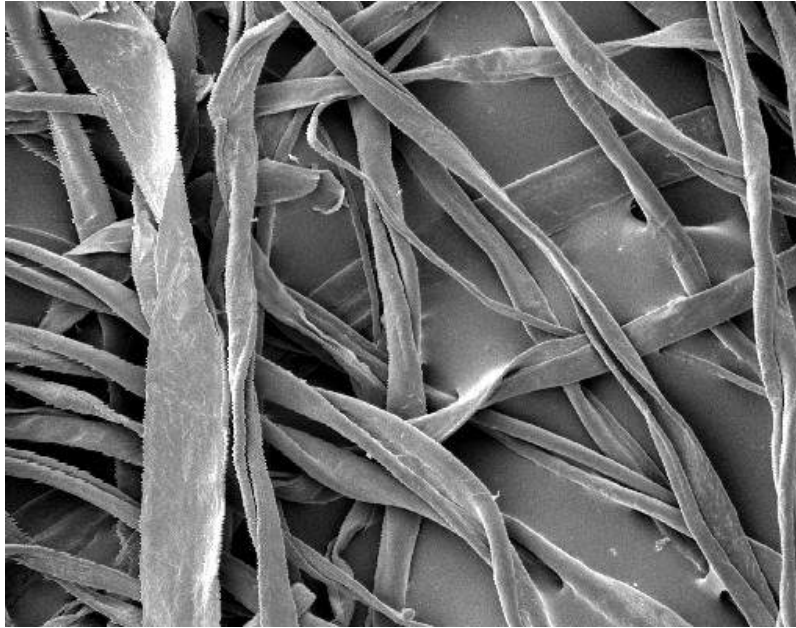


There are general weave patterns associated with making a textile. The **leno** weave is a loose, open weave that resembles a figure of eight pattern and is easy to alter. The **plain** weave is firm but may wrinkle. The basket weave is quite flimsy and shrinks when washed. The **twill** weave feels soft upon touch and is one of the most durable weaves. The **satín** weave is another pattern that is not so resilient and may appear shiny.

Type of Weave	Diagram	Description	Characteristics
Plain		Alternating warp and weft threads	• firm and wears well • snag resistant • low tear strength • tends to wrinkle
Basket		Alternating pattern of two weft threads crossing two warp threads	• an open or porous weave • does not wrinkle • not very durable • tends to distort as yarns shift • shrinks when washed
Satin		One weft crosses over three or more warp threads.	• not durable • tends to snag and break during wear • shiny surface • high light reflectance • little friction with other garments
Twill		Weft is woven over three or more warps and then under one. Next row, the pattern is shifted over one to the left or right by one warp thread	• very strong • dense and compact • different faces • diagonal design on surface • soft and pliable
Leno		This uses two warp threads and a double weft thread. The two adjacent warp threads cross over each other. The weft travels left to right and is woven between the two warp threads.	• open weave • easily distorted with wear and washing • stretches in one direction only

Natural Fibers

Natural fibers are obtained from either plant or animals. The most common of the plant fibers is cotton. It is found in abundance in clothing which makes it somewhat invaluable if found at a crime scene. Certain characteristics that are imparted upon the fabric such as processing techniques and treatments of various colors help to make the fibers a bit less similar, which would increase its value in an investigation. Microscopically, cotton will appear ribbon-like due to all the twists found within the fiber.



Cotton (ribbon-like)

Other plant fibers used include flax (used to make linens), ramie (used to make sewing thread, packing materials, fishing nets, filter cloths, upholstery, canvas, clothing in conjunction with wool, silk, or cotton, and in production of paper), sisal (used in linen rugs), jute (used to make ropes), hemp (rope/sacks), kapok (pillows and mattress stuffing), and coir (used in carpet/rugs). These fibers are not commonly found, especially in making clothing. The revelation of these infrequent fibers through cross transfers between a victim and suspect would prove to be very valuable pieces of evidence.

Animal Fibers

The most common animal fiber is wool derived from sheep. Fibers that are fine and less abrasive are used to make clothes, while the thicker, more abrasive fibers are used in carpeting. Wool fibers may also be obtained from llama, camel, alpaca, and goat (cashmere and mohair). It may be easy to differentiate which animal the fibers came from by studying the diameter and scale structure of the hair shaft. Silk (from silkworm) is used to make clothing, luxurious materials, and furniture. Fibers used to make fur come from mink, rabbit, and beaver.



Wool coronal cuticle



Silk Fiber: left fiber: fracture, right fiber: crossover indentation.

Synthetic Fibers

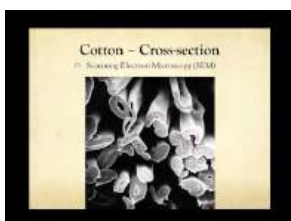
Synthetic fibers are man-made fibers. They generally have taken over the textile industry. Over half of all fabrics produced for clothing and goods are made from these types of materials. Some man-made fibers are made from natural raw materials (regenerated cellulose) such as rayon, acetate, and triacetate. Nylon, polyester, and acrylic are made from synthetic chemicals. Polyester and nylon are the most abundantly used of the man-made fibers.



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Examination of Fibers

Flame Tests

A flame test helps to determine the identity of an unknown fiber. It must be noted that most revelations at crime scenes involve the discovery of minimal numbers of fibers. It would not be wise to use flame tests if an abundant sample is not found. The following observations should be noted, and tests should be performed:

- **Texture:** Classify the fiber as smooth, rough, coarse, fuzzy, soft, sheer, or slippery.
- **Approaching flame:** Holding the fiber in the forceps, bring it close to, but not touching the flame. Describe the fiber's behavior as it approaches the flame. Does it begin to ignite, melt, or curl?
- **In the flame:** Holding the fiber in the forceps, touch the fiber to the flame. Does it ignite quickly or slowly?
- **Reaction to being in the flame:** While in the flame, does it flare, shrink, sizzle (sometimes two simultaneous reactions are noted)?
- **Removed from flame:** Remove the fiber from the flame and describe how it behaves. Does it self-extinguish or continue to burn?
- **Odor:** Note any odor associated with the fiber in a flame. Does it smell like burning hair (bad odor), burning paper, or burning plastic?
- **Residue:** What kind of residue is left after the fiber is removed from the flame? Does the fiber leave a fluffy ash, a hard bead, or a bead that turns into ash?



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Comparison Microscope

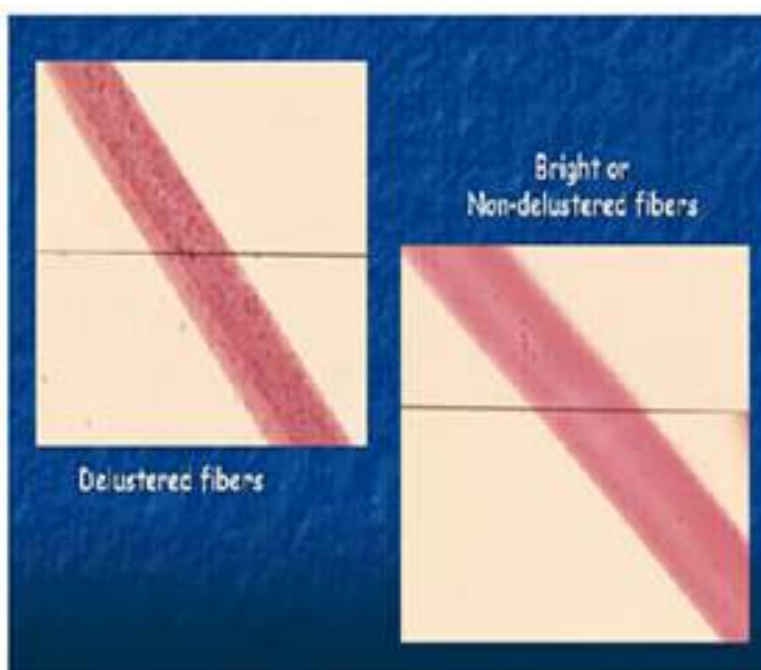


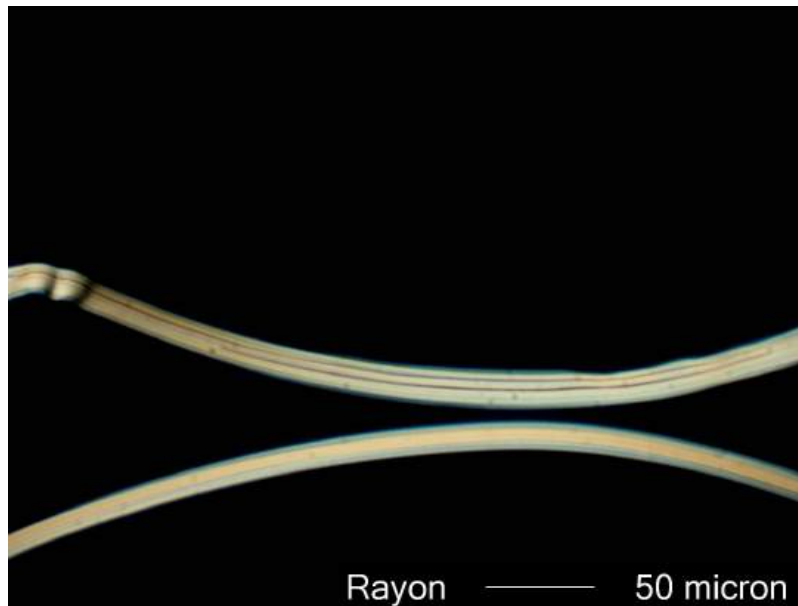
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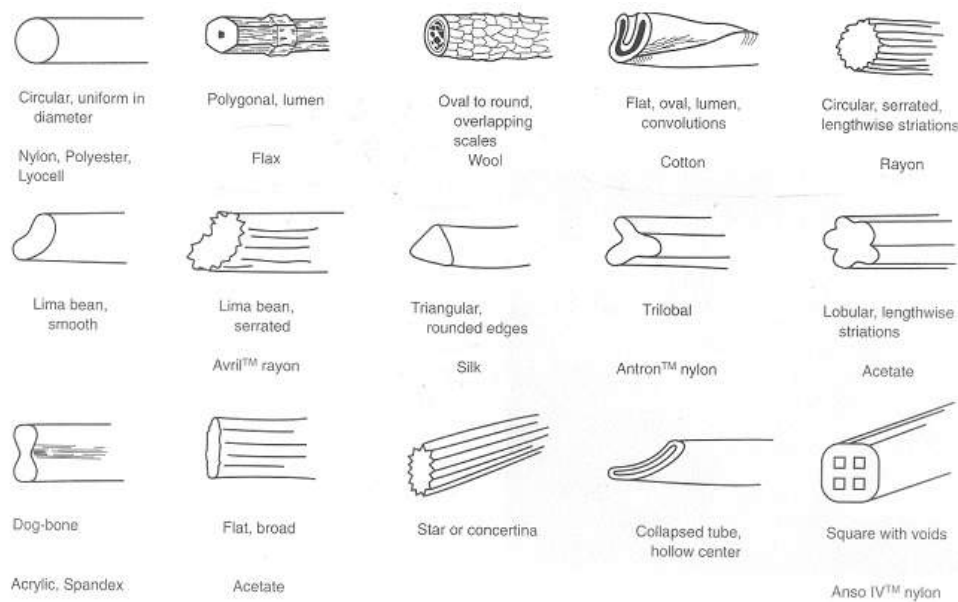
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The examination of fibers usually begins by viewing fibers through a comparison microscope. An unknown sample is placed on one of the stages, and the known sample is placed on the other. Both fibers are viewed side-by-side. The color, diameter, characteristics such as **lengthwise striations** (lines that span the length of the fiber), **delustering particles** (titanium dioxide granules that look like speckled pepper grains which help to reduce shine), and cross section are noted to see if there could be a potential match. Nylon is a fiber that has high amounts of delustering particles. Rayon and polyester contain both delustering particles in smaller amounts compared to nylon, and lengthwise striations.





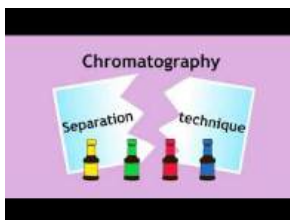
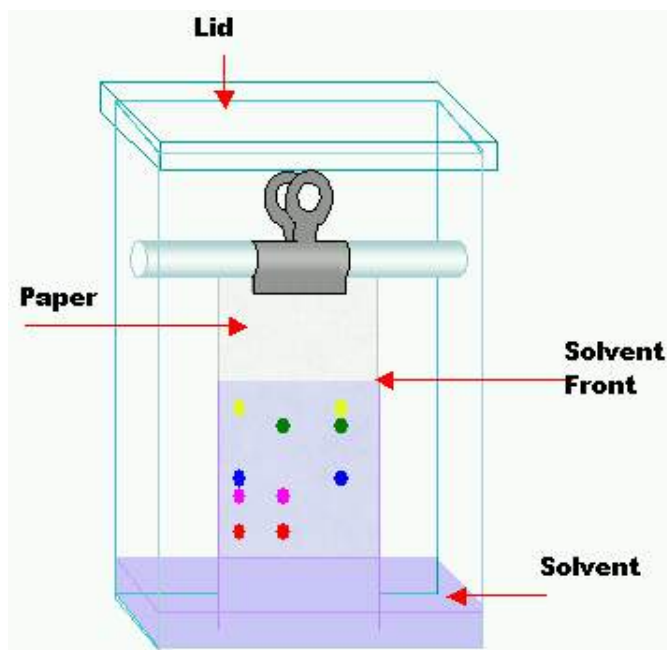
Lengthwise striations



Cross sections from <http://imgarcade.com/1/wool-fiber-cross-section/>

Chromatography

A solvent is used in order to separate the dyes used in a fiber to achieve a specific shade. The dyes travel up a filter paper. Once the dyes have been separated, a comparison is done to determine if there are any similarities in the dyes that were used. In the picture shown below, the chromatogram shows that there is no correlation between the three fibers tested.



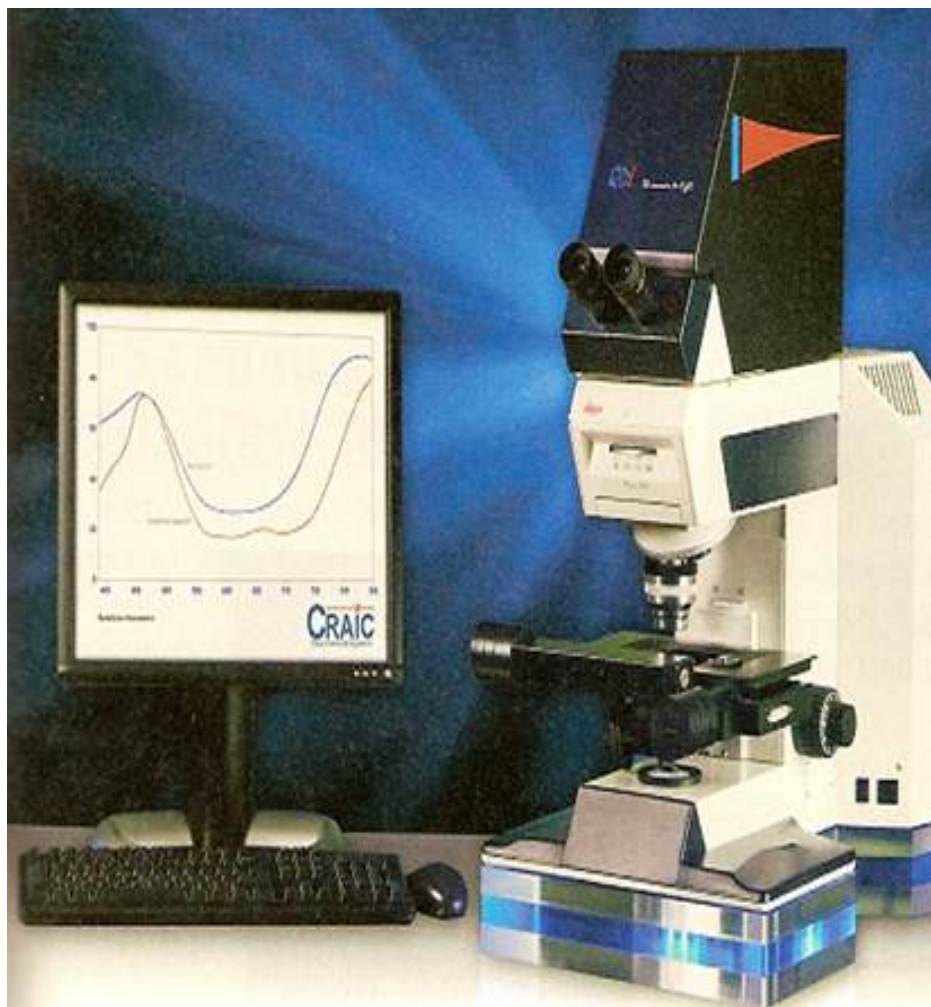
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Microspectrophotometer

Mixtures of different dyes are combined in order to achieve a specific shade. A **visible light microspectrophotometer** measures the spectra (color differences) of microscopic samples based on the absorption of light at different wavelengths and may be used to determine if the combinations of dyes in one fiber corresponds to the combination of dyes in the other fiber. A read out is given by the computer in the form of a graph to show whether the colors originated from the same basis or not. In the picture shown below, the graph shows that there is no correlation between the first and second sample.

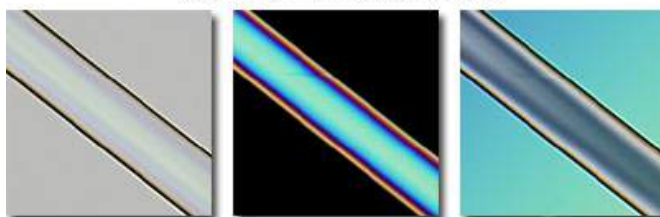


from <http://www.microspectra.com/>

Polarized Light Microscopy

Polarized light microscopy uses polarized light to determine **birefringence** (difference between two refractive indices). Each plane of light has a refractive index, which can be revealed by placing a fiber in a fluid that has the same refractive index. With a polarizing microscope, the vanishing of the Becke line is viewed. The parallel and perpendicular indices are subtracted from one another to determine the birefringence. Synthetic fibers are made by melting or dissolving a substance and running this solution through a spinneret in order to produce the actual fiber. This imparts a crystal-like appearance which is viewed microscopically with the polarized light.

Nylon Fiber in Polarized Light



from <https://www.microscopyu.com/articles/polarized/polarizedintro.html>

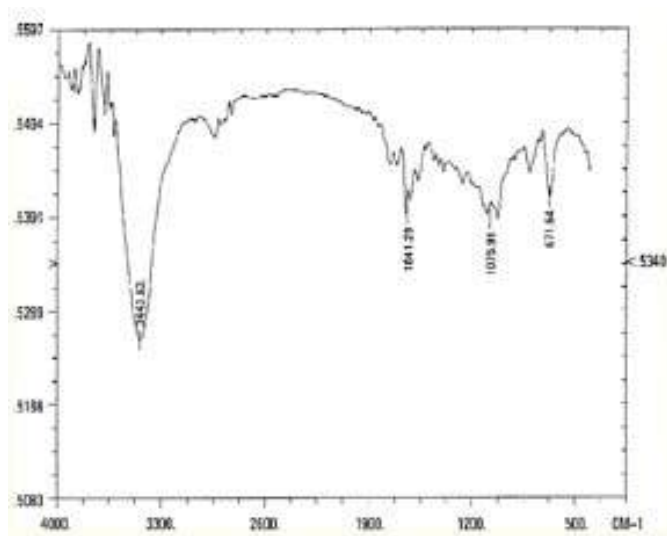
Refractive Indices

TABLE 6.1:

Fiber	Parallel	Perpendicular	Birefringence
Diacetate	1.474-1.479	1.473-1.477	0.002-0.005
Triacetate	1.469-1.472	1.468-1.472	0.000-0.001
Acrylic	1.510-1.520	1.512—1.525	0.001-0.005
Rayon (viscose)	1.541-1.549	1.520-1.521	0.020-0.028
Nylon 6	1.568-1.583	1.525-1.526	0.049-0.061
Nylon 6.6	1.577-1.582	1.515-1.526	0.056-0.063
Polyester (PET)	1.699-1.710	1.535-1.546	0.147-0.175
Polyester (PBT)	1.688	1.538-1.540	0.148-0.150

Infrared Spectroscopy

Infrared spectroscopy analyzes a fiber's chemical composition based on its capacity to attract light at different wavelengths, which then produces specific patterns depending on the class of fiber. A small sample is required and it may be identified as a specific class of fiber or may even be classified down to the subclass of fiber.





MEDIA

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URL: <http://www.ck12.org/flx/render/embeddedobject/168716>

Magnitude of Evidence

The more fibers that are found at a crime scene or on a suspect, the greater the chance that there has been contact between two people, or a person and the site where the crime occurred. A fiber that has come from a common type of material will almost diminish its value. The more unique a fiber is due to it not being commonly used to make textiles, the higher value it will have in linking a culprit to the crime scene. Trying to prove without a doubt that a fiber came from a specific garment is quite difficult. Scientists compare so many aspects of fibers that one may be able to say that the fiber may have come from a known sample, or it did not come from the known sample.

Collection and Preservation of Evidence



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- Loose fibers are collected with clean forceps.
- The fiber is to be folded in a paper (druggist fold) and then placed in an envelope to ensure that no fibers will be displaced.
- Clothing should be packaged in separate paper bags.
- All clothing and fibers collected from different people must not come into contact.
- Carpets, rugs, and bedding should be folded to protect areas suspected of containing fibers.
- Tape lifts on any surface that may questionably contain fibers may also be done to ensure that no samples are left behind.
- If a body was wrapped in a carpet or blanket, tape lifts must be done on the body.
- Vacuum sweepings can be done to ensure that nothing is left behind at the crime scene.
- The whole vacuum bag will be sent to the lab for analysis.

**MEDIA**

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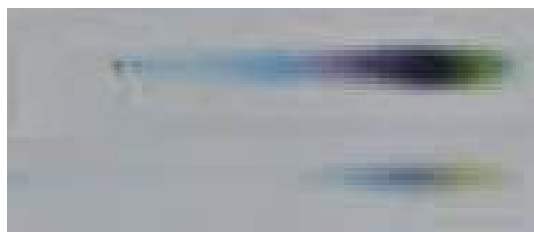
Chapter Summary

- A fiber is a small and thin piece of string in which its length is quite bigger than the diameter.
- Yarn is a collection of fibers that are twisted together. These collections of fibers are then taken to create a textile, which literally becomes the fabric itself.
- A weave is generated by a lengthwise fiber being interlaced by a horizontal fiber.
- The lengthwise fiber is known as the warp, and the horizontal is known as the weft.
- There are general weave patterns associated with making a textile such as leno, plain, basket, twill, and satin weaves.
- One classification of fibers is a natural fiber that is derived from plant or animal origin.
- The other category is a synthetic fiber that is made from natural raw materials such as regenerated cellulose (examples of these fibers are rayon, acetate, and triacetate), or synthetic chemicals (nylon, polyester, or acrylic).
- A flame test helps to determine the identity of an unknown fiber.
- The color, diameter, lengthwise striations, delustering particles and cross section are noted through a comparison microscope to see if there could be a potential match between two fibers.
- Chromatography is used to separate the dyes used in a fibers to see if the same dyes were used in an unknown and known sample.
- A visible light microspectrophotometer measures color differences of microscopic samples based on the absorption of light at different wavelengths and may be used to determine if the combinations of dyes in one fiber corresponds to the combination of dyes in the other fiber.
- Polarized light microscopy uses polarized light to determine birefringence (difference between two refractive indices).
- Infrared spectroscopy analyzes a fiber's chemical composition based on its capacity to attract light at different wavelengths, which then produces specific patterns depending on the class of fiber.
- The more fibers that are found at a crime scene or on a suspect, and the more unique the fiber is, the higher value it will have in linking a culprit to the crime scene.
- Scientists compare so many aspects of fibers that one may be able to say that the fiber may have come from a known sample, or it did not come from the known sample.
- Collecting and packaging evidence is of utmost importance when dealing with fiber evidence.

Review Questions

Short Answer

1. Why would a white cotton fiber found at a crime scene and a white cotton fiber found on a suspect that looks similar to the one at the crime scene not be sufficient to link the suspect to the crime?



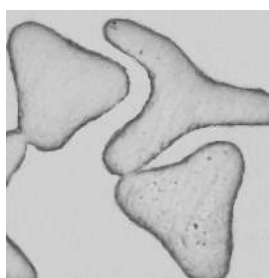
2. Two fibers are gathered, one from the homicide victim, and the other from a potential suspect. What information can be inferred from the chromatography results on these two samples? Explain.
3. The refractive indices of two fibers have been obtained. Based on the results of the birefringence, which may be the identification of these two fibers? Explain.

TABLE 6.2:

Fiber one: 0.025
Fiber two: 0.059

True or False

4. True or False: The leno weave pattern is characteristic of the picture shown above.



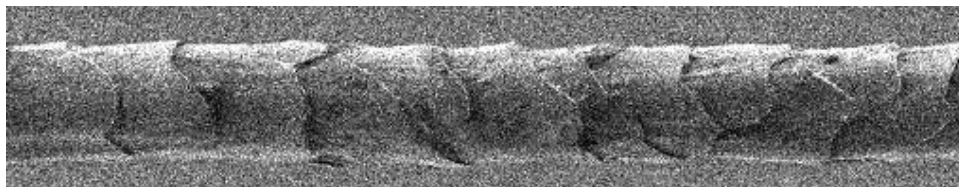
<http://www.microlabgallery.com/gallery/images/Nylon17bXSecfixed.jpg>



5. True or False: Based on the microscopic features of the fiber shown above, this may be classified as a synthetic fiber, and the subclass of fiber is nylon.
6. True or False: A visible light microspectrophotometer analyzes a fiber's chemical composition based on its capacity to attract light at different wavelengths, which then produces specific patterns depending on the class of fiber.

Multiple Choice

7. Which of the following are not examples of manufactured fibers?
- A. Spandex
 - B. Cashmere
 - C. Acetate
 - D. Mohair
8. A criminalist is collecting fiber from a crime scene. She locates fibers on the victim's shirt and jeans and places both of these in separate plastic bags. She also sees fibers on a rug near the victim, so she tape lifts the fibers and places them in a plastic bag. Noticing fibers stuck to the glass door, which is the possible suspect's entryway, she removes the fibers with forceps and places them in a container. What mistake was made while the evidence was collected?
- A.. She followed all collection procedures correctly including placing clothing in separate bags, using tape lifts on fibers, and using forceps to obtain fiber from the windowsill.
 - B. She made a mistake when packaging the clothing. All clothing should be placed in the same paper bag especially when these items belong to the same individual.
 - C. She made the mistake of performing tape lifts of fibers on the sheet. The only evidence that requires tape lifts are fingerprints.
 - D. She correctly removes the fibers from the glass door with forceps but fails to package them correctly. These fibers must be placed in a small sheet of paper, folded and labeled, then placed in a separate container.



9. This fiber is recovered from a crime scene. Which type of fiber does this evidence resemble?
- A. Cat
 - B. Horse
 - C. Silk
 - D. Wool



from www.microlabgallery.com

10. This is recovered from a crime scene. Which type of hair or fiber does this evidence resemble?

- A. Human head hair due to its curly nature.
 - B. Rayon due to the striations and titanium dioxide present.
 - C. It is pubic hair due to its short, curly nature.
 - D. It is cotton because of its ribbon-like pattern.
-

References

1. <http://cool.conservation-us.org/jaic/img/jaic26-01-003-fig002.jpg>. .
2. <http://www.microlabgallery.com/gallery/images/Rayon13Ac.jpg>. .
3. <http://imgarcade.com/1/wool-fiber-cross-section/>. .

CONCEPT 7

Unit 6 Serology

TEKS

- (10) The student analyzes blood spatter at a simulated crime scene. The student is expected to:
- (B) explain the method of chemically identifying and locating an invisible blood stain using reagents such as luminol.
- (12) The student explores serology laboratory procedures in forensic science. The student is expected to:
- (A) explain forensic laboratory procedures to determine if a stain detected in a crime scene is blood;
- (B) identify the red blood cell antigens and antibodies as they relate to human blood types;
- (C) determine genotypes and phenotypes in the human red blood cell system using Punnett Squares; and
- (D) research methodologies used to collect and analyze other body fluids.

Objectives

In this chapter, topics will be explored such as:

- blood's brief history
- the composition of blood
- blood typing and transfusions
- heredity
- detection of blood
- the characterization of semen
- collection, preservation, and packaging of biological evidence.

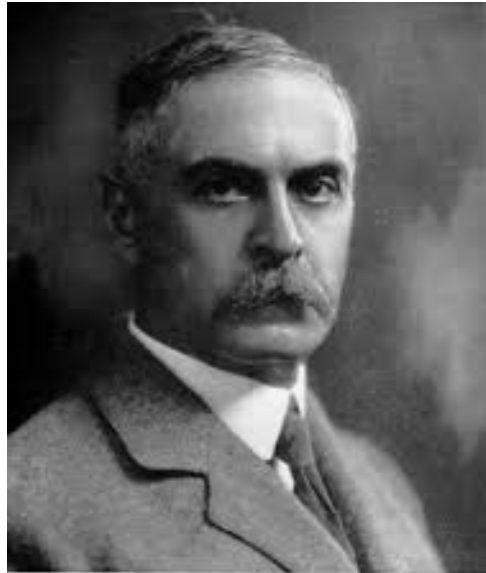
Introduction

Forensic serology is the analysis of body fluids, e.g. blood, semen, saliva, tissue, feces, and urine in relation to a crime scene. Most often, these fluids are analyzed for the presence of DNA, and thus may link a suspect to a crime scene. Blood is the most common type of evidence found in crimes such as assaults, sex cases, and homicides.



History

In 1900, Karl Landsteiner described the **coagulation** (clotting) of blood when one person's blood was mixed with another. He thought that this was due to the nature of the person's blood. In 1901, he found that some serum would cause blood from a different person to **agglutinate**, or clump. This was a huge discovery, which later became known as blood typing. He also was able to determine that not all blood was the same. He grouped blood into A, B, and O and two of his colleagues discovered the AB blood type. This is now known as the A-B-O blood system today. By 1940, the Rhesus (Rh) factor was also discovered. Roughly 85% of the population exhibit the factor, while it is absent in others.



K. Landsteiner

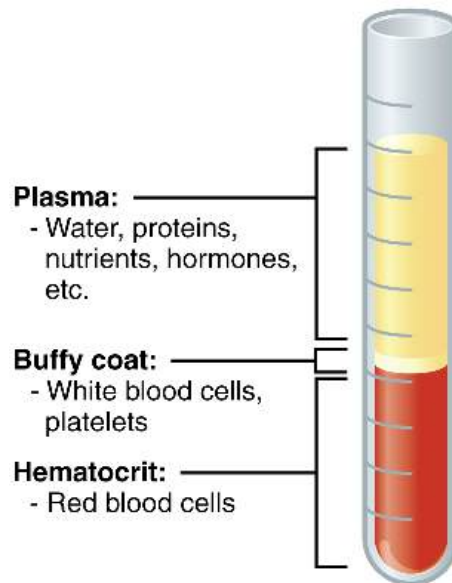
THE ABO BLOOD SYSTEM				
Blood Types	Type A (AA, AO)	Type B (BB, BO)	Type AB (AB)	Type O (O)
Proteins on Red Blood Cell Surface				

The A-B-O system became the primary means by which to tie a suspect to a crime scene. We now know that this is ineffective because millions of people may have the same blood type. Later, with the advent of DNA, blood could now be individualized to a single person.

Blood Composition

Blood is a mixture of **plasma** and solids. Plasma is the liquid portion of unclotted blood and comprises 55% of the blood content. Plasma is mainly made of water, but also carries electrolytes, hormones, protein (antibodies), wastes, vitamins, nutrients, and gases. Once a clot is formed, the liquid portion is no longer known as plasma, but is now called **serum**. The solids (45%) consist of three types of cells: **red blood cells**, **white blood cells**, and platelets.

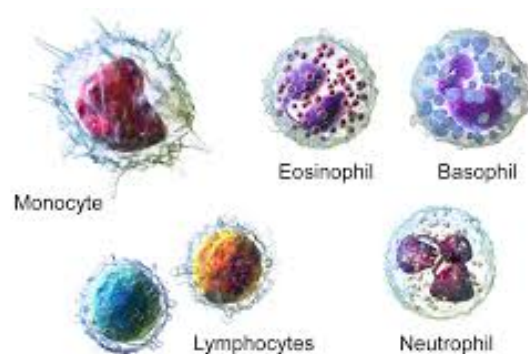
The function of the RBC is to transport anything vital to a cell's existence, such as oxygen, to the cell, and get rid of wastes. WBCs are our line of defense and immunity.



How is it that DNA can be determined by testing one's blood? Red blood cells are round and have a zone of central pallor when viewed in a microscope. In 3-D, the cells are still round, but have a depression in the middle which creates the central pallor. It is consequently evident that a red blood cell is devoid of a nucleus. Red blood cells do have a nucleus during the maturation process, but lose it once it is ready to enter the bloodstream as a mature red blood cell. White blood cells also travel mixed with red blood cells and platelets in the bloodstream. A white blood cell is the only cell that contains a nucleus. It is for that reason that a WBC is the source for DNA when determining the identity of an unknown blood sample left at a crime scene or to establish paternity.



Red Blood Cells



White Blood Cells

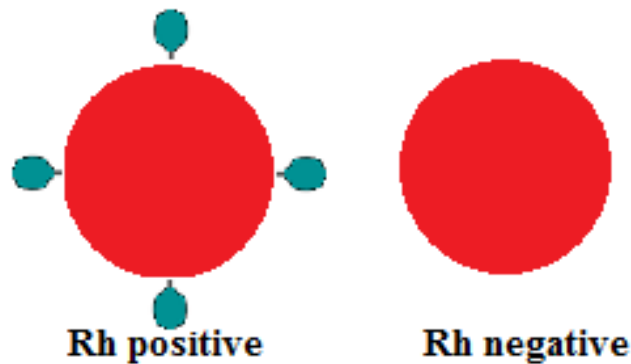
Antigens and Antibodies

Many **antigens** are found on the surface of red blood cells. They are chemical structures more commonly known as proteins. The ABO and Rh systems are the most important antigens found on the RBCs. They are both accounted for in routine blood typing tests.

If a person has A proteins (antigens) on the surface of the cell, they have blood type A. If a person has B proteins (antigens) on the surface of the cell, they have blood type B. If a person has A and B proteins on the surface of the cell, they have blood type AB. Respectively, if no antigens are present, the blood type is O.

	Group A	Group B	Group AB	Group O
Red blood cell type				
Antibodies in Plasma			None	
Antigens in Red Blood Cell	A antigen	B antigen	A and B antigens	None

The Rh factor, or D antigen, is also tested for routinely in a blood typing test. People that possess this antigen on the surface of the RBC are said to be Rh positive. Those that are missing the antigen are called Rh negative. For example, if a person is O positive, they will possess the D antigen, and if the person is O negative, they will lack D antigen.



Serum contains proteins called **antibodies**. An antibody is produced by the body's immune system when it detects harmful antigens. Each antibody is exclusive and defends the body against one antigen. An **antiserum** is a serum that contains known antibodies.

An antigen cannot have the same antibody, or it would attack itself. It therefore has to have an antibody that is opposite its antigen. Blood type A has A antigens and B antibodies. Blood type B has B antigens and A antibodies. Blood type AB has both A and B antigens and is absent of any antibodies. Respectively, type O lacks antigens and contains both A and B antibodies.



Video

MEDIA

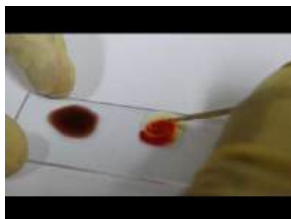
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Blood Typing

Blood typing reveals which type of blood a person has. Forward typing and reverse typing are performed in a medical laboratory to confirm a person's blood type. In **forward typing**, the patient's blood (antigen) is tested against antibodies from an antiserum, and is checked for agglutination. Three antisera are used, anti-A, anti-B, and anti-D and are mixed with the patient's blood. A blood clumps with anti-A, B blood clumps with anti-B, AB clumps with both antisera, and O does not clump with either.





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In **reverse typing**, the patient's serum (antibody) is tested against known antigens, A cells and B cells. If the A cells agglutinate, that means that the serum contains A antibodies. The blood group that contains A antibodies is blood group B. If the B cells agglutinate, the serum contains B antibodies, and therefore is blood type A. AB blood does not have any antibodies, so it will not clump against the A or B cells. O has both antibodies, and will clump with both A and B cells. Refer to the following table and video for complete understanding of forward and reverse blood typing.

TABLE 7.1:

Anti-A serum	Anti-B serum	Anti-D serum	A blood cells	B blood cells	Blood type
+	-	+	-	+	A pos
+	-	-	-	+	A neg
-	+	+	+	-	B pos
-	+	-	+	-	B neg
+	+	+	-	-	AB pos
+	+	-	-	-	AB neg
-	-	+	+	+	O pos
-	-	-	+	+	O neg

+ denotes the presence of agglutination, while the – stands for the absence of agglutination.



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Transfusion s



Blood Transfusion

A blood type is usually performed for a patient that is waiting to receive a blood **transfusion**. A transfusion of blood may be required to replenish any blood lost during surgery, injuries, or illnesses. The following table lists which blood types a donor may donate to and which types a recipient may receive.

RELATIONSHIPS BETWEEN BLOOD TYPES AND ANTIBODIES				
Blood Type	Antigens on Red Blood Cell	Can Donate Blood To	Antibodies in Cerum	Can Recieve Blood From
A	A	A, AB	Anti-B	A, O
B	B	B, AB	Anti-A	B, O
AB	A and B	AB	None	AB, O
O	None	A, B, AB, O	Anti-A and Anti-B	O

Transfusing the wrong blood type can cause coagulation and ultimately, death. For example, if AB blood is given to a type A patient, the B antibodies from the A recipient will bind to the A antigens from the donor's AB blood, resulting in a clot. Vice versa, if A blood is given to type AB, this will result in a compatible donation. AB blood does not possess antibodies, so there will be nothing to bind onto an incoming antigen. AB is therefore known as the **universal recipient** because it can receive blood from all four groups. O can only receive blood from another O, but may donate to all blood groups because of the lack of antigens. This is known as the **universal donor**.

Rh factors are also taken into consideration when determining a compatible match for a transfusion. Rh positive blood may donate to only Rh positive patients. Rh positive, on the other hand, may receive from both Rh positive

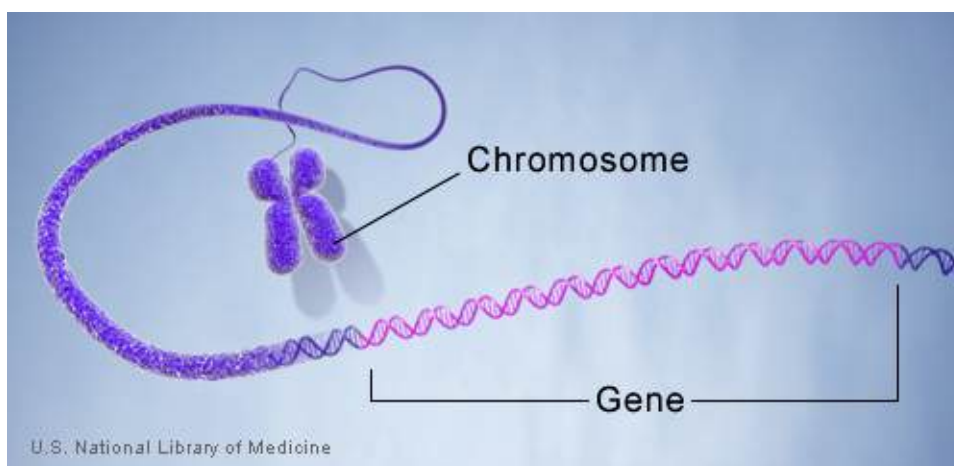
and Rh negative blood. Rh negative blood may donate to Rh negative and Rh positive patients, but may only receive from Rh negative blood. For example, A+ blood may receive from A+, A-, O+, and O- blood. A+ may only donate to A+ and AB+ patients.

RED BLOOD CELL COMPATIBILITY TABLE								
Recipient	Donor							
	O-	O+	A-	A+	B-	B+	AB-	AB+
O-	✓	✗	✗	✗	✗	✗	✗	✗
O+	✓	✓	✗	✗	✗	✗	✗	✗
A-	✓	✗	✓	✗	✗	✗	✗	✗
A+	✓	✓	✓	✓	✗	✗	✗	✗
B-	✓	✗	✗	✗	✓	✗	✗	✗
B+	✓	✓	✗	✗	✓	✓	✗	✗
AB-	✓	✗	✓	✗	✓	✗	✓	✗
AB+	✓	✓	✓	✓	✓	✓	✓	✓

Heredity/Paternity

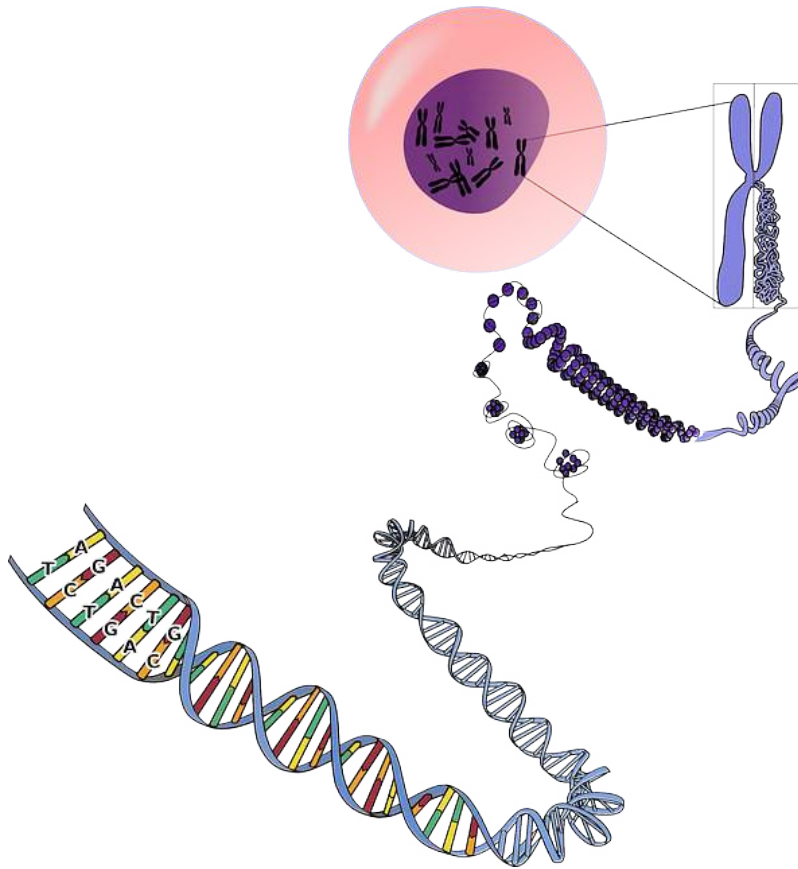
Heredity is the passing on of genetic traits that produce specific qualities within an organism. These traits are what make all living things completely different, not only from unrelated organisms, but also from their closest relatives. Every characteristic within an individual is genetically inherited, along with blood types.

Genes



Genes are made up of DNA and are known as the basic unit of heredity. Each gene is composed of the **base pairs** adenine, thymine, cytosine, and guanine. These base pairs are known as **purines** and **pyrimidines**. Purines are two-ringed structures. The two base pairs that are purines are adenine and guanine. Pyrimidines are only made of a one-ringed structure. They are thymine and cytosine. These base pairs, along with phosphate and five-carbon sugars,

known as deoxyribose, make up the DNA double helix. DNA is then wound up to form our chromosomes, which are found in the cell's nucleus.



Alleles

Genes are inherited in pairs. One gene comes from the mother, while the other is inherited from the father. This pair joins together at a particular location on the chromosome to transmit a specific characteristic onto the offspring, such as having or not having a cleft chin. Not having a cleft chin is known as a **dominant** trait, while having a cleft chin is a **recessive** trait. Dominant traits are expressed when at least one copy of the gene is expressed. A recessive trait is only expressed if two copies are inherited. If the two genes inherited are the same (e.g., TT or tt), the trait is **homozygous**. If they are different (Tt), they are **heterozygous**.



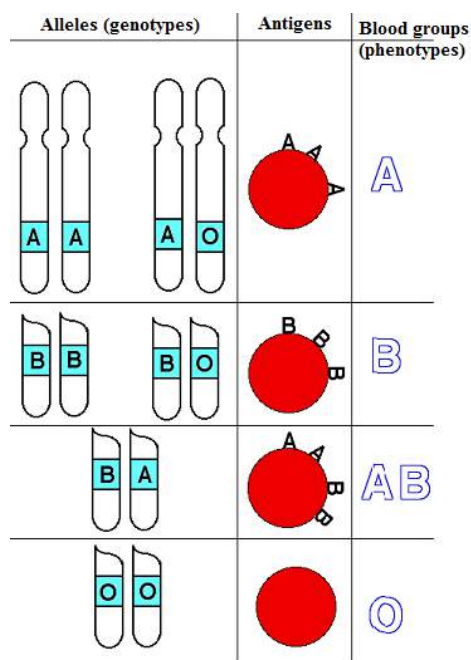


Some traits are not so cut and dry as dominant and recessive traits. Other characteristics may be controlled by multiple alleles (more than one version of a gene). Blood is known to have three **alleles**, I^A (A), I^B (B), and i (O). A and B are codominantly expressed, and O is recessive. For example, a person that has “A” and “B” alleles will have blood type AB. A person with a “B” allele and an “O” will be blood type B. B is dominant over the recessive allele O, as a result, the B will be expressed and the O is concealed. The following table lists the different allele combinations and their respective blood types.

TABLE 7.2:

Allele 1	Allele 2	Blood Type
A	A	A
A	O	A
A	B	AB
B	O	B
B	B	B
O	O	O

A person’s **genotype** is its internal code. An example of a genotype would be AO. A person’s **phenotype** is the outward, physical manifestation of an organism. Since the example shows us that the genotype possesses the letters “A” and “O”, the outward manifestation of the organism is that this person has “A” blood.



Paternity

No child may bear a specific blood type that is not found in at least one of the parents. Many paternity cases may be resolved by comparing both parents' blood types. This would save the otherwise expensive cost of performing a DNA test prematurely. If the father's blood type does not coincide with the child's blood type, this would exclude him as being the father. No further DNA testing would be required. If there is a possibility that he is the father, then he can't be excluded. This would follow with proper DNA testing to reject or confirm him as the true father.

This can be done by knowing what the phenotypes are and determining their genotypes as well. Let's say that the mother is type A, the father has type O, and the child in question has AB blood. Could he really have fathered this child? Let's take a closer look. Now, the genotypes for type A blood could either be homozygous, AA or heterozygous, AO. The father's genotype is OO. The possible outcomes for their children can be predicted using a Punnett square.

Mother - A homozygous		A	A	
Father - O blood	O	AO	AO	Or
		AO	AO	

Mother - A heterozygous		A	O	
Father - O blood	O	AO	OO	
		AO	OO	

If the mother is homozygous for A blood, 100% of their kids would be heterozygous for A blood. This means that they carry the codominant A allele and the recessive O allele. Since O is recessive, the A allele will be expressed and all kids will have the A blood type. If the mother is heterozygous for A blood, 50% of their children will be A heterozygous and 50% will have O blood.

So, in regards to paternity, could the male be excluded as the possible father? He absolutely can. There is no possibility that the mother and father in either situation above could have produced AB offspring. He can be eliminated as the father without having to perform a DNA test. What if the child has A blood? There is a possibility in either situation that he could be the father. A DNA test would have to be performed to ultimately state whether he fathered the child or not.



MEDIA

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Detection of Blood

If blood is suspected at a crime scene, a presumptive test must be performed to give us the possibility that the stain being examined is actually blood. If we have a positive presumptive result for blood, the next step is a confirmatory test to prove without a doubt, that the stain is blood. The next step is to determine if the blood present is of human origin. If it is human blood, then the most important question lies on who the blood came from.

Presumptive Tests

In a presumptive test, a negative result indicates that the sample being examined is not blood. A positive result presents that it is more than likely blood. Many substances may yield false-positive results and therefore must be confirmed when a positive result is indicated. Presumptive tests produce different color reactions or may produce light through chemiluminescence or fluorescence. These tests rely on the presence of hemoglobin in blood to produce a color change. Sometimes, enhancement is needed to produce a more visible reaction that would be better seen in a photograph. Some tests are no longer used today because they are known to be carcinogens and have been replaced with the following tests.

Color Tests

The **Kastle-Meyer** test combines the blood stain, K-M reagent (ethyl alcohol, sodium hydroxide, zinc and phenolphthalein), and hydrogen peroxide. A deep pink color produced within 5-20 seconds is evidence for the presence of blood. Many items may give false positive reactions such as horseradish, potatoes, chemical oxidants, and some metals but these items do not produce an immediate color change. Time can be a strong indicator as well as color change when determining if the substance is potentially blood, or is just a false-positive reaction. A great attribute of the Kastle-Meyer test is that it is sensitive to dilutions of blood. The only drawbacks to using this test are that it is not specific to only blood and it may reduce the amount of recoverable DNA.



MEDIA

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Hemastix is typically used to test for blood in urine samples, but can also be used at crime scenes to test blood. It involves a plastic strip with a TMB (tetramethylbenzidine) and hydrogen peroxide containing pad at one end. To perform the test, a sterile swab is wet with distilled water and rubbed over a bloodstain. The swab may then be placed on the Hemastix reagent pad. The original color of the pad is yellow and a color change to green or blue-green is assumed to be blood. As with the Kastle-Meyer test, a color change will be produced very quickly. A color change due to the presence of blood will occur in less than thirty seconds using Hemastix. This test is sensitive to dilutions of blood. It is not specific and false positives may occur with chemical oxidants, metals such as copper and iron and certain food items. DNA could be recovered from stains once they have been tested with this method.



MEDIA

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The **Leucomalachite green** (LMG) test combines blood, LMG reagent, and hydrogen peroxide. A blue-green color change indicates the presence of blood. Leucomalachite green is as specific to blood as the Kastle-Meyer and luminol, but its sensitivity is less. It is not as sensitive as Hemastix. It also destroys DNA once it is applied to the bloodstain.



Many technologies have come about to produce more test kits to presume that an unknown sample at a crime scene may be blood. Some examples are Hemident and Sangur. These tests use the same principles as the tests discussed above. They depend on the oxidation reaction of hydrogen peroxide which oxidizes a colorless substance into the evolution of a colored substance.

Chemiluminescence Tests



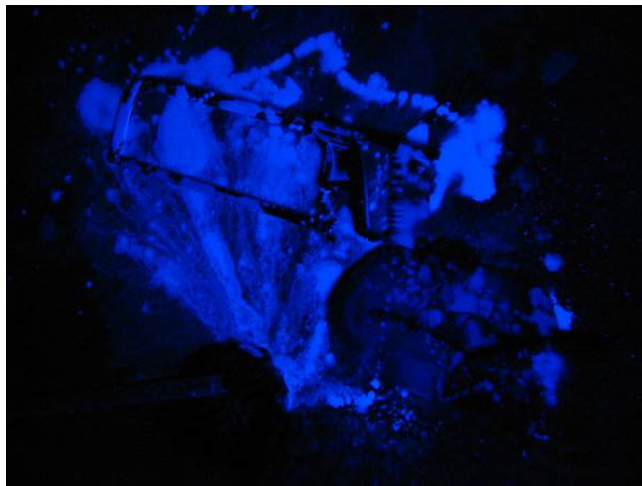
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Luminol's crystals are mixed with hydrogen peroxide and a base to form a liquid, which is then sprayed onto a bloodstain. The hemoglobin in blood will cause the solution to glow blue. It is very important to note that the room

that the solution is sprayed in must be dark to notice the glow. Once sprayed, the reaction will be quick, but the reaction will only last a short time. It is very important to take a good picture to retain for future reference. It may also require an enhancement treatment to capture a better visual. Luminol is intensely sensitive and can pick up blood in areas where it appeared that no blood was present, or areas that were cleaned. It does not destroy blood cells if further testing is required, but may eliminate other evidence that is close to the area being sprayed. Some substances may cause false positive reactions such as copper, feces, bleach, and food items.

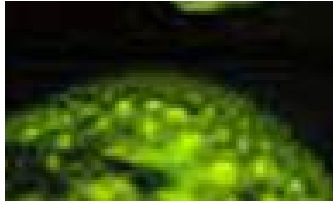


Bluestar is based on the luminol chemistry, but perfects the formula to eliminate the drawbacks of using luminol. Its preparation is easier because all that is needed to be done is to dissolve a tablet in solution. It also does not require extremely dark areas to see the luminescence as luminol does. As with every presumptive test, false positive reactions do occur but it is much easier to differentiate blood's reaction versus a false positive. This is due to the radiance that is produced by blood, which is a bright color and it lasts a longer period of time. False positives do not yield the same reaction. No enhancement is needed for photography, as the pictures taken of blood treated with Bluestar will be visible enough. It is extremely sensitive and can be used on areas that have been previously clean. It also does not hinder blood typing or DNA testing.



Fluorescein can be purchased as HemaScein or Flora-Scene. These vendors make the preparation really easy. Adding distilled water to the prepared formulation (Fluorescein and zinc) is all that is really needed and it is then sprayed onto a large crime scene area for the detection of blood. To visualize the fluorescence, the investigator must use a UV light source and goggles and examine for the presence of a green glow. Some benefits of using this product

are that it can be applied in partially darkened rooms, it is also as sensitive as luminol, and it does not destroy DNA. A drawback of using this substance is that the reaction time will only last approximately five minutes. It also can have false-positive results with cleaning agents and metals.



Chemical Enhancement

The enhancement of a bloodstain still focuses on a substance reacting with hemoglobin to produce a color change. A common chemical enhancement used is called **LCV**, or **Leucocrystal Violet**. If blood is present, the reaction will produce a purple to blue color. This method helps to make the evidence easier to see. A photograph can then be taken which will provide a visual with greater detail for future analysis.



Confirmation Tests

Confirmation tests are performed to prove that without a doubt, a substance being tested is blood. These tests are based on the foundation of forming crystals when the reagent added to the blood sample binds to a certain portion of the blood. Although they do prove blood's identity, as with all testing, they do pose some limitations. These tests are not sensitive like the presumptive tests. If there is a negative result, it doesn't inevitably mean that blood isn't there. Moreover, a larger sample than that used for a presumptive test is needed. If the stain is small, it would be wise to run a presumptive test so that a sample could be left for further testing. Some substances could inhibit the production of crystals (tannins from wood or leather; rust), whereas others could produce false positive results (plant peroxidases and bacterial catalases), although rare.

Teichman Test

The Teichmann test was discovered in 1853 and confirms that a sample obtained is actually blood. It is a microcrystalline test based on the creation of hematin crystals. A sample of blood is placed on a microscope slide and covered with a coverslip. Teichmann's reagent is then added onto the slide. This reagent contains mainly glacial acetic acid along with small amounts of KCl, KBr, and KI. The slide is then heated for twenty seconds. A positive test for blood will reveal brown ferroporphyrin crystals observed through the use of a microscope.

Takayama Test

This test was discovered in 1912 and is the most used confirmatory test of the two discussed. It is a microcrystalline test based on the production of hemochromogen crystals. The test is the same as that discussed for the Teichmann

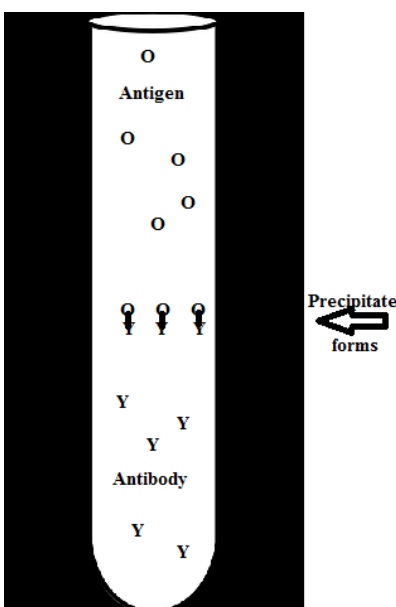
test, but with the addition of Takayama reagent. The main components of the reagent are distilled water, pyridine and small amounts of 10% NaOH and glucose. A positive test for blood will exhibit pink hemochromogen crystals microscopically.

Species Identification

Once a sample is confirmed to be blood, the next step is to determine which species the blood came from. The basis behind this test is to determine if the sample is human blood so that further testing can be done to determine who the sample came from, thus linking a suspect to a crime. This method of testing relies on serum antibodies reacting with antigens from the unknown blood sample to form a precipitate. The two tests that will be discussed are the precipitin test and gel diffusion.

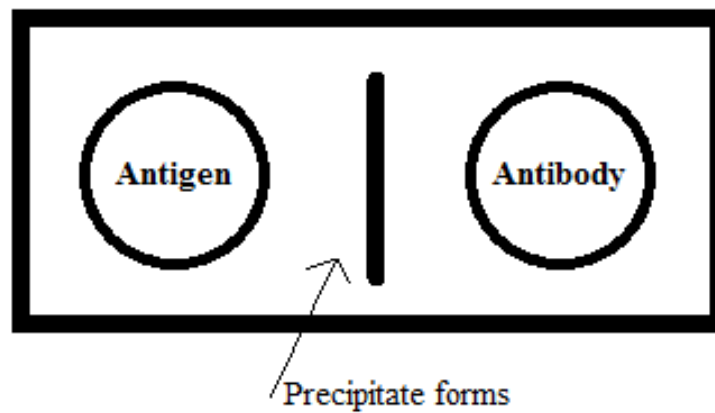
Precipitin Test

Every species is known to have different antigens. This is the basis behind the precipitin test. Laboratories have prepared antisera (antibodies) for the most common animals found in homes, along with human antisera. If a sample found at a crime scene has tested positive for blood (which contains antigens), then the precipitin test will follow. Human antiserum is added to a test tube and then the suspect blood is added on top. If a band forms in between the two samples, this precipitate indicates that the sample is of human origin. The next step is to individualize the blood sample.



Gel Diffusion

Gel diffusion also relies on antigen and antibody reactions. Human antiserum is placed on one end of a gel plate and the unknown blood sample is placed on the opposite side. If the samples migrate towards one another and form a precipitate, then the sample is of human origin. DNA testing would be the next step in order to determine who the sample came from.

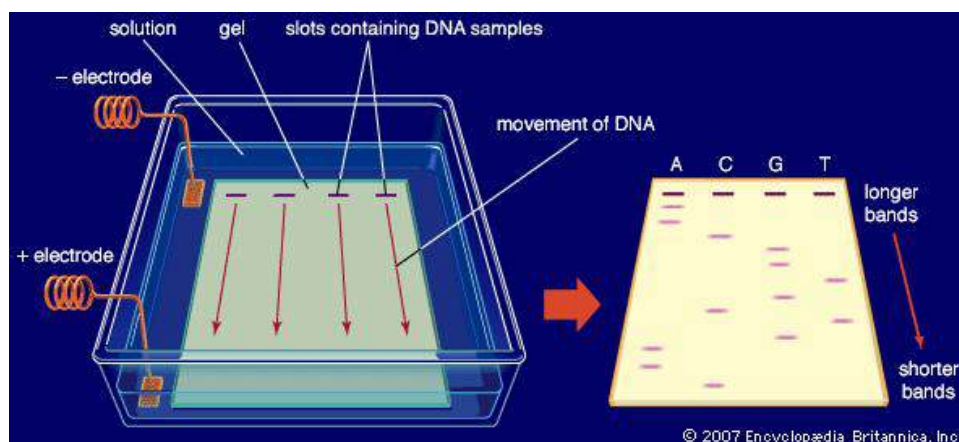


Individualization

Blood markers used to be the primary means in which to tie a sample to an individual. Since the discovery of DNA testing, blood markers are no longer used. DNA electrophoresis is the means by which an unknown sample can be tied to an individual.

DNA Electrophoresis

A gel electrophoresis is used to separate DNA based on size. An electrical source needs to be applied to get the DNA to form and move bands. A gel needs to be prepared and placed in a buffer. With a micropipette, DNA samples (e.g., unknown sample from a crime scene, a suspect's sample and a control called a ladder) are added along with a denaturing agent and loading dye. Once the samples are loaded, a power supply is connected to the apparatus. DNA has a negatively charged phosphate backbone and will migrate toward the anode (positive charge) side of the apparatus. Small molecules will travel through the gel swiftly and will end up further away from the starting point. Larger molecules will not move that far and will form bands much closer to the starting point. This method allows DNA to be examined based on the separation of the bands. This can either link a suspect to a crime scene, or vindicate anybody that may have been unjustly blamed.



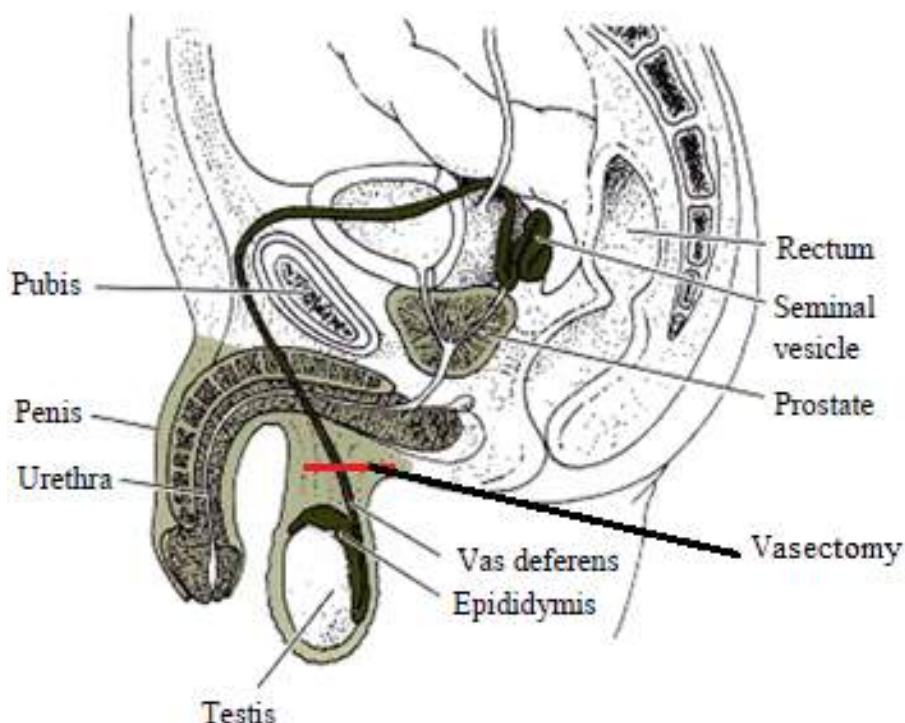
Semen

Semen is a combination of seminal fluids from the prostate gland, seminal vesicle, epididymis, and bulbourethral glands along with sperm. Males typically release millions of sperm per ejaculation. The chance of locating sperm is high, but there are instances upon examination that may yield a sample with an absence of sperm.



The absence of sperm or low counts can occur due to various reasons. A dry sample on clothing or bedding needs to be rubbed gently to release any intact sperm or may be immersed and agitated in water. If rubbed too hard, the chances of the cells breaking apart will be great. Sometimes, a sperm sample may be bound so tight to clothing that immersing it in water will not release the individual cells.

There are other instances that will reduce counts such as medical issues, diet, age, and illegal and legal drug use. Males may produce lower than normal counts of sperm, which is known as **oligospermia**. A male may also be infertile, producing no sperm, a situation known as **aspermia**. Males that have had a **vasectomy**, which is a procedure to sever the vas deferens to prevent the transfer of sperm, will also produce ejaculations that are absent of sperm. These types of individuals discussed will still be able to discharge seminal fluids.



Semen is an invaluable sample that can provide information on who may have executed an unwarranted sex act. The key lies in identifying a sample. Most stains are visible due to the characteristic off-white to yellow, crusty appearance against a dark background. Stains on light surfaces may need to be revealed using light sources such as blue lights or ultraviolet lights. When samples are exposed to these lights, a seminal stain will fluoresce. Once a sample has been located, the next step lies in testing.

Seminal Analysis

Acid phosphatase, also known as the **Brentamine Spot Test**, is a test that produces a color change, which indicates a positive result for seminal fluid, but does not necessarily reveal the presence of individual sperm cells. It is an enzyme that is produced by the prostate gland. It is found in high amounts compared to anything else that may yield a false positive reaction. For example, vaginal secretions and some contraceptive creams may yield positive results, but will produce that result in far more time than compared to a true seminal stain.

The test can be performed in wells on a spot plate or may be done on filter paper. The latter will be explained. A sample of the stain is rubbed onto the filter paper. A few drops of a solution of sodium alpha naphthylphosphate and Brentamine Fast Blue are placed on the filter paper. A positive result will yield a purple coloration very rapidly. Anything that turns that color over a long period of time is a strong indication that a false positive result has been obtained. It is extremely important to test the sample containing a possible seminal stain within 24 hours. Anything above that time will diminish its presence and may be extremely difficult to detect the enzyme at all.



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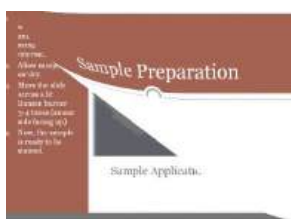
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MUP (4-methylumbelliferone phosphate) is a test that produces fluorescence under UV light when it converges with acid phosphatase. This test proves that seminal fluid is present, but does not reveal the presence of sperm cells. Testing is very similar to the acid phosphatase test. Filter paper is rubbed over a seminal stain and then is taken to a darkroom. A sample of the test solution is sprayed onto the filter paper and UV light is applied. Fluorescence indicates the presence of the enzyme found from the secretions of the prostate gland. This test is also considered to be more sensitive than the Brentamine test.

Christmas Tree Stain

Once a presumptive color or fluorescence test has given a positive result for seminal fluid, the next step is to confirm the presence of sperm cells. A microscopic slide will need to be prepared and heat fixed. Nuclear Fast Red is applied onto the microscopic slide for fifteen minutes. Picroindigocarmine is then added onto the slide for about fifteen seconds and is rinsed with methanol. Nuclear Fast Red will stain the sperm head red and picroindigocarmine stains the tail green. This slide is then viewed microscopically for the presence of these nicely colored sperm cells. Sperm cells start to break down once ejaculated into the vaginal cavity. The quicker the sample is taken, the greater chance there is in locating intact sperm.



MEDIA

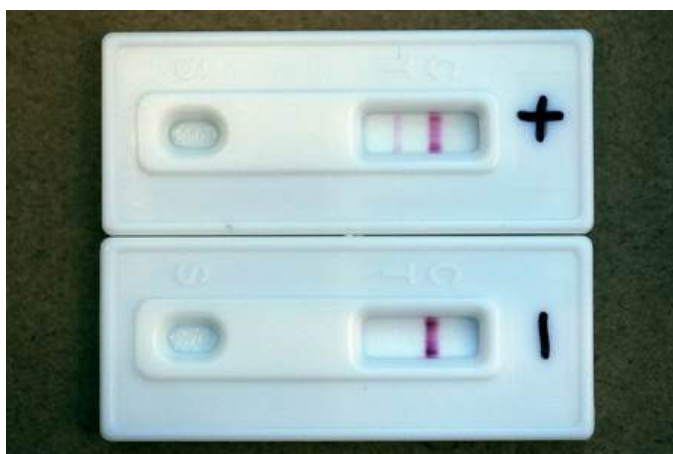
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A positive presumptive test and identification of sperm cells equates that a sex crime has been committed. Now, the sample can be DNA tested to determine who the sample belongs to. This will ultimately lead us to the revelation of who committed the sexual assault.

Moreover, there are times in which there is a positive presumptive test, but a microscopic identification of sperm is absent. Remember, as discussed above, males may be aspermatic, have low counts of sperm termed oligospermia, may have had a voluntary procedure performed called a vasectomy, or the dry sperm sample may have been rubbed too hard, disintegrating any intact sperm cells. In any of these cases, antigen-antibody tests may confirm that semen is present when no sperm are located.

ABAcord® p30 detects Prostate Specific Antigen in human semen when no sperm are visually detected. The test contains an antibody that reacts with p30 in seminal fluid. If the antibody and antigen come together, they will produce pink bands in the testing area. Two bands (one for the control and one for the actual test) show a positive result, whereas one band (the control should always have a band present to indicate that the test strip is actually working) will show a negative result. The ABA card is sensitive to dilutions of 1:2048-8192 and the cost for each test is very favorable. Sometimes there may be other substances that contain PSA, such as breast milk, but in much smaller amounts. Although this test is sensitive to great dilutions of PSA found in semen, its specificity may be a drawback. PSA can persist in the vaginal cavity for only up to twenty-four hours. The earlier the sample is taken, the better the results.



**MEDIA**

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Rapid Stain Identification of Human Semen (RSID™-Semen) is highly specific for semenogelin in human seminal fluid (which produces the gel-like consistency of sperm) when no sperm are seen. The test has an antibody that reacts with semenogelin in seminal fluid. This will produce red banding in the testing region. Two bands, one for the control and one for the antibody present in the sample, will indicate a positive result. One band, only for the control, will be interpreted as a negative result. The RSID test is sensitive to dilutions of 1:1024-2048. Semenogelin is specific to seminal fluid therefore, false positive results should not be found.

**Protocols for Collecting, Packaging, and Preserving Rape Evidence**

After a rape has occurred, many women almost feel responsible for the attack. They may feel shameful and would rather not report the incident. Feelings of being dirty are also common, and many women's first thoughts are to shower, washing away all remnants of a rape. Time is of the essence when reporting these crimes due to the viability of the sample that needs to be collected. Living sperm may survive up to six hours in vaginal cavity and non-motile sperm may be found up to six days after intercourse. Sperm with tails still attached are not normally found after sixteen hours, but have been found up to seventy-two hours, even though it is not common.

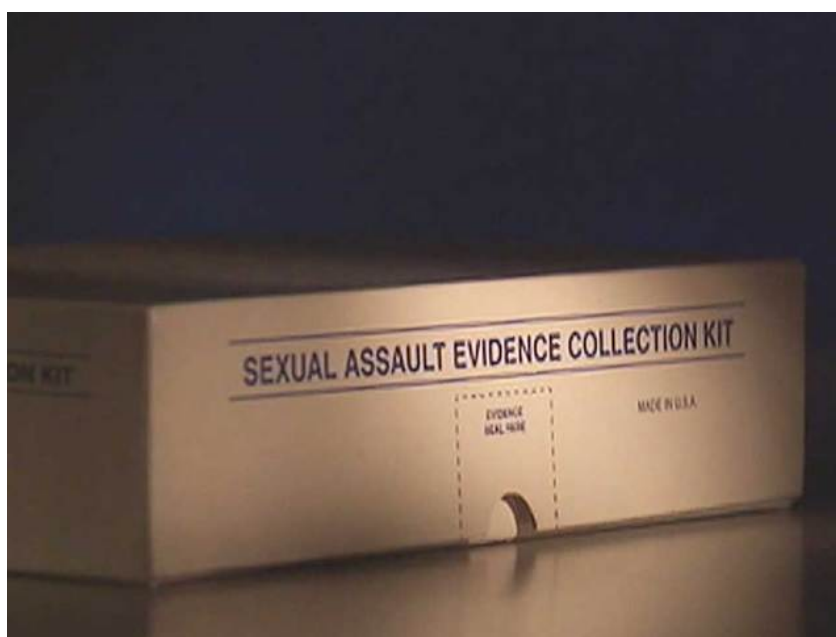
In some cases, the person committing the sexual assault may not have ejaculated or may have worn a condom and no semen will be found in or on the victim. Not locating seminal evidence doesn't necessarily mean that there will not be a conviction on the basis of rape. Let's examine the case of Army Private Tracy McBride.



Louis Jones, Jr., a decorated war veteran, kidnapped McBride from the Goodfellow Air Force Base in San Angelo, TX in 1995. He raped and bludgeoned her to death. He later confessed that he was responsible for her murder, but didn't initially admit to raping her. Upon examination by the medical examiner, Dr. Jan Garavaglia, she was able to determine that a sex crime did occur, in which he later admitted. The presence of semen was never found, but genital injuries were found such as bruising and contusions. With these findings, prosecutors were able to seek the death penalty for Jones. He was executed on March 18, 2003.

Many sexual assault cases may have some vital pieces of evidence missing, such as the seminal stain. It does not mean that a rape was not committed, but other physical evidence may be found such as injuries, hair, fibers, or blood to help prove that a rape did take place. The key is to locate these pieces of evidence in a timely manner to form a link between a suspect and victim.

A rape kit is used to collect any vital evidence and is then handed over to the crime lab. The kit has items such as instructions, evidence bags, the sheet the victim stands on while disrobing, swabs, combs, envelopes for trace evidence, needles, disinfectant, and vacutainers for blood collection, and forms to document any and all pertinent information.



A forensic medical exam is usually performed at a hospital. The person stands on a sheet to remove clothing. Anything that falls off the clothing, such as hair or fiber, will surely land on the sheet initially placed on the floor. Clothes are collected and placed in separate paper bags so that the items are allowed to dry if they are damp. The sheet is then folded and placed in the rape kit for transfer to the crime lab and is analyzed for any trace evidence. Any sheet or comforter on which the rape occurred should be submitted to the lab as well. A total body exam, both externally and internally, will be completed.



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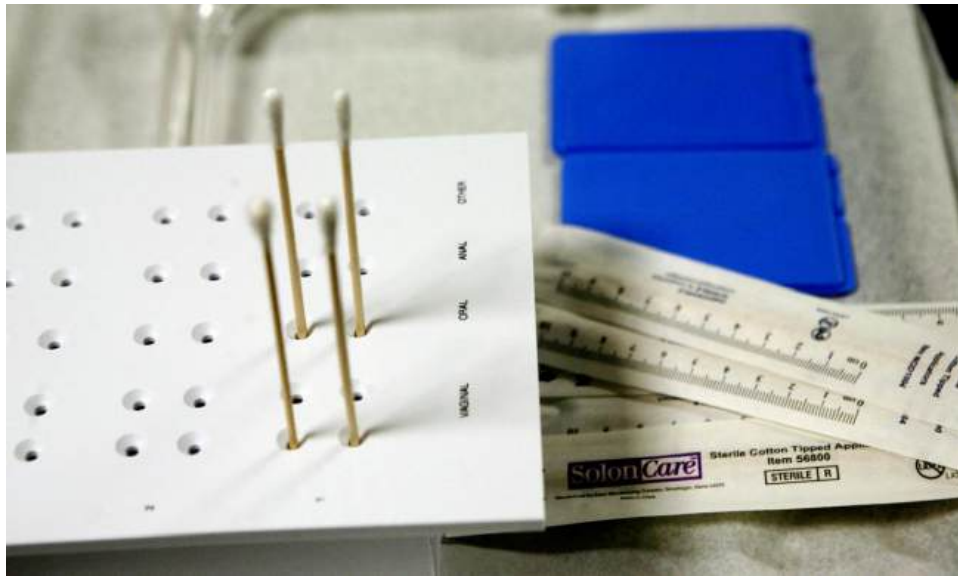


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Other samples that need to be collected from the victim are pubic combings, pubic hair, vaginal swab and smears, cervix swabs, rectal swabs and smears, oral swabs and smears, head hair, blood, fingernail scrapings, urine, and saliva residue from skin (used to test for suspect's DNA). If there is a suspect in mind, samples that need to be obtained from this individual are clothing (especially underwear that was worn during the assault), pubic hair combings, pulled head and pubic hair, penile swab within 24 hrs, blood sample, and buccal swab.



Chapter Summary

- Forensic serology is the analysis of body fluids, e.g. blood, semen, saliva, tissue, feces, and urine in relation to a crime scene.
- Karl Landsteiner discovered blood groups and came up with the ABO classification system.
- Blood is composed of liquid and solids. The liquid may be classified as plasma or serum depending on whether or not a blood sample has clotted. The solids are red blood cells, white blood cells, and platelets.
- Antigens are chemical structures more commonly known as proteins and are found on the surface of red blood cells. Antigens are antibody specific and these two may complex and form clumps, or may clot blood entirely.
- Serum contains proteins called antibodies. Antiserum may be produced in laboratories and contains antibodies towards a specific antigen.
- Blood typing reveals which type of blood a person has. Three antisera are used, anti-A, anti-B, and anti-D and are mixed with the patient's blood. A blood clumps with anti-A, B blood clumps with anti-B, AB clumps with both antisera, and O does not clump with either. Blood that clumps with anti-D is Rh positive and blood that does not clump with this antiserum is called Rh negative.
- A blood transfusion may be required to replenish any blood lost during surgery, injuries, or illnesses. It is extremely important to know which blood types a donor may donate to and which types a recipient may receive.
- Genes are composed of base pairs, along with phosphate and five-carbon sugars, known as deoxyribose, make up the DNA double helix. DNA is then wound up to form our chromosomes, which are found in the cell's nucleus.

- Alleles are versions of a gene that may be genetically passed on to offspring.
- There are many civil cases that involve determining paternity, e.g., whether or not a man truly fathered a child.
- If blood is suspected at a crime scene, a presumptive test must be performed to give us the possibility that the stain being examined is actually blood. If we have a positive presumptive result for blood, the next step is a confirmatory test to prove without a doubt, that the stain is blood. The next step is to determine if the blood present is of human origin. If it is human blood, then the most important question lies on who the blood came from.
- DNA electrophoresis is the means by which an unknown sample can be tied to an individual.
- Semen is a combination of seminal fluids from the prostate gland, seminal vesicle, epididymis, and bulbourethral glands along with sperm. This sample is of utmost importance in sexual assault cases.
- There are many color tests that may yield a presumptive identification of semen. They must be followed by a confirmatory test, such as the identification of the sperm cell. If no sperm cells are found, specific antigen-antibody reactions need to be performed to identify the sample as containing semen.
- Time is of the essence when reporting rape crimes due to the viability of the sample that needs to be collected. A rape kit is used to collect any vital evidence and is then handed over to the crime lab.

Review Questions

Short Answer

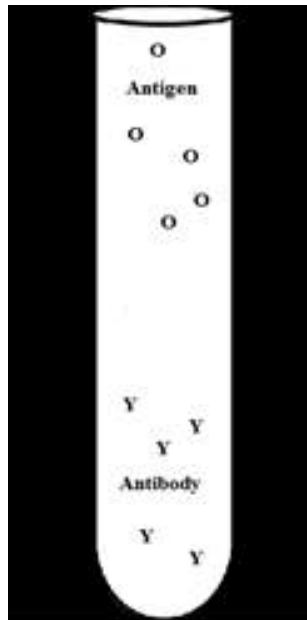
1. What may be found in our blood's liquid portion? What is this portion called and what percentage of blood does this constitute?
2. What may be found within blood's solids? What percentage of blood do these cells comprise?



3. The ABACard® p30 test was performed on a seminal sample. What do the results indicate? Is this test considered to be valid or invalid?
4. DNA is found within a cell's nucleus. How is it possible to extract DNA from blood if the red blood cells are anucleated? Explain.
5. According to one's blood, where are antigens found? Antibodies?
6. A person with type A blood is in need of a transfusion. O blood is the only blood available in the laboratory. What would happen if this O blood unit is transfused into the person with type A blood? Explain your answer. Also, what would occur if the person has O blood and A blood is to be given to them via transfusion (make sure to include donor antigens and antibodies and recipient antigens and antibodies in the explanations).
7. A possible seminal stain has been recovered from a sexual assault. The acid phosphatase test is performed and yields the production of a purple color within 20 seconds. The next step is to identify intact sperm cells visually

through a microscope using the Christmas Tree Stain. What may be at least four possible reasons as to why sperm cells may not be recovered?

8. A person is Rh positive. Would it be safe to transfuse Rh negative blood? May a person with Rh negative blood receive Rh positive blood (explain your answer using terminology such as donor antigens and antibodies and recipient antigens and antibodies)?



9. A red sample has been identified at a crime scene. The Kastle-Meyer test is performed and it produces a bright pink color, indicating a positive presumptive test for blood. The next step is to determine whether this sample is of animal or human origin using the precipitin test. Human antiserum is added to a test tube and the blood sample is added on top of that. The results are shown above. Is this blood sample of human origin? Explain your answer.

10. What are the most important questions that an investigator must ask when processing a possible blood stain?

11. A forensic nurse practitioner is in the process of performing a rape kit from a sexual assault victim. The victim is brought into the room and is asked to remove her clothing. After the clothing has been placed in separate plastic bags, a sheet is placed on the floor and the victim is asked to stand on it while the nurse obtains other pieces of evidence from her body such as hair, blood samples, oral and vaginal swabs. Has the nurse violated any collection procedures? If so, identify and correct the errors to ensure that evidence collection is done properly.

12. Which blood types may a B patient receive? Which types may this B patient donate to?

13. A victim is found bludgeoned to death in a vehicle. The vehicle does not have any blood in it other than what is dripping from the victim. The police are not able to find any identification. Using the license plate number, the investigators are able to locate the victim's address. They report to the home that night and smell cleaning agents as soon as they walk into the door. Which presumptive test would be the best indicator to show that blood is present in the home even though the crime scene may have been cleaned? Explain your answer.



14. A DNA gel electrophoresis has been performed on four samples. The first column of bands shown is from a rape victim's vaginal swab. The next three columns represent three suspects that may be involved with this crime. They have volunteered to provide buccal swabs to test against the rape victim's sample. May any of the three be exonerated from the crime? May any of the three be guilty of raping the female? Explain your answers thoroughly.

Multiple Choice

15. What is the basis behind the Kastle-Meyer test for identification of blood?

- A. Blood, phenolphthalein reagent, and hydrogen peroxide are mixed together. Oxidation of hemoglobin produces a pink color.
- B. The strip is moistened with distilled water and is placed in contact with a bloodstain. A green color change indicates the presence of blood.
- C. Spray the bloodstain with reagent and darken the room. A faint blue luminescence indicates the presence of blood.
- D. Place a drop or two of the solution containing alpha naphthylphosphate and Fast Blue dye into the stain in question. A purple color indicates the presence of blood.

16. Police note that a blanket at a sexual assault crime scene shows evidence of a white, crusty substance. They take it to a lab to test for semen. One investigator notices that there is there evidence of an overturned bowl of watermelon close to the blanket. The lab uses the acid phosphatase test to test for the presence of semen. Five minutes after completion of the test, the blanket shows a purple color. Should they conclude that there is a presence of semen?

- A. No, the test is specific. A false positive reaction can occur with other substances.
- B. Yes, the purple color indicates a positive reaction showing the presence of semen.
- C. No, watermelon is known to cause a false positive reaction. Furthermore, if semen were present, the reaction should have occurred under 30 seconds.
- D. Yes, the test is specific for semen. Only semen can yield a positive reaction.

17. Study the genotypes of the child in question's mother, father, and grandparents. Determine the paternity of the

father for the child in question:

Mother: A	Maternal grandmother: B	Maternal grandfather: A
Father: B	Paternal grandmother: AB	Paternal grandfather: A

Child in question: O

- A. He is not the father because he would have to be type O to have a type O child.
 - B. There is a 25% chance that he is the father. DNA testing is required for confirmation.
 - C. There is a 50% chance that he is the father. DNA testing is required for confirmation.
 - D. He is not the father. These two individuals can only produce A, B, and AB children.
18. If a person has type O blood, which antigen is bound to the red blood cell and which antibody is found in the plasma?
- A. The RBC will have B antigens and A antibodies in the plasma.
 - B. The RBC will have A and B antigens and will not possess antibodies in the plasma.
 - C. The RBC will not possess antigens, but will contain A and B antibodies in the plasma.
 - D. The RBC will have A antigens and B antibodies in the plasma.



19. Based on the visual provided above, which blood type does this person have?
- A. A negative
 - B. AB positive
 - C. O negative
 - D. B positive
20. The persistence of semen and or sperm in the vagina may help determine the time of the alleged sexual attack. If motile sperm are found, how long ago did the attack occur?
- A. 6 hours

- B. 24 hours
- C. 12 hours
- D. 36 hours

Blood typing/transfusion interactive game:

<http://www.nobelprize.org/educational/medicine/bloodtypinggame/gamev2/index.html>

t 6

CONCEPT

8

Unit 6 Blood Pattern Analysis

TEKS

(10) The student analyzes blood spatter at a simulated crime scene. The student is expected to:

(A) analyze blood stain patterns based on source, direction, and angle of trajectory.

Objectives

In this chapter, topics will be explored such as:

- BPA introduction

Blood stain basics such as:

- Terminology
- Surface texture
- Height
- Direction
- Impact angles
- Types of blood stains (passive, transfer, projected/impact)
- Other types of stains
- Area of convergence and point of origin
- Evidence documentation and collection
- Crime scene reconstruction

Introduction

Bloodstain pattern analysis (BPA) is the examination and analysis of bloodstains left behind at a crime scene and the interpretation of how those stains are produced. An analyst must be very well-versed on the topic. They must understand the complexities of how blood behaves overall, along with how it behaves upon exit from the body. They need to be knowledgeable on how blood will look once it hits different types of target surfaces. Ultimately, one of the most important jobs of the analyst is to determine which types of events could cause a specific stain, thus understanding the proceedings that occurred throughout the entire time span of the crime. They may also help in recreating the crime scene for further analysis.

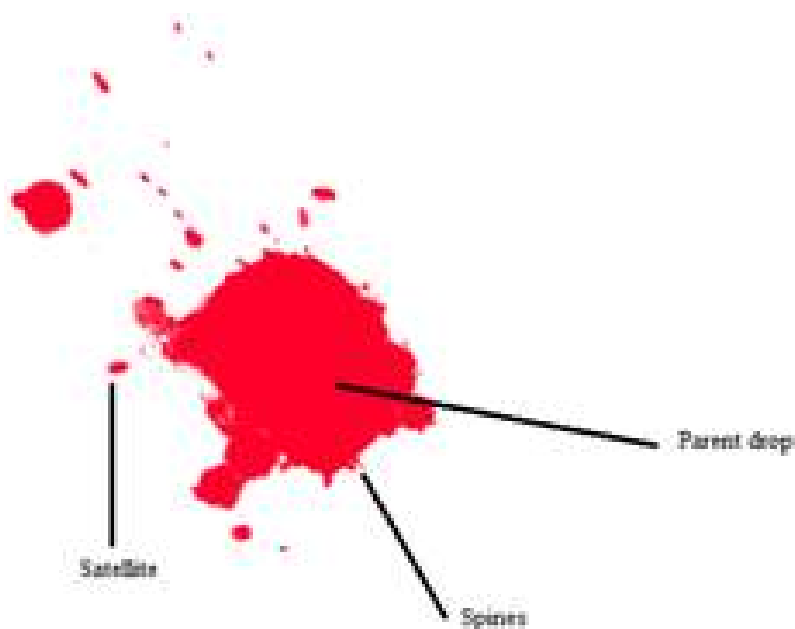
BPA integrates many disciplines. Aspects of math such as trigonometry and geometry are routine, along with biology, chemistry, and physics in the science realm. From within these disciplines, certain questions are bound to be asked, such as:

- Which direction did the blood come from?
- At which angle did the blood drop hit the surface?
- Where were the victim and suspect located?
- How many blows did the victim receive, and from which direction did they receive them?
- What caused the wounds on the victim's body?
- Which movements were made after the wounds were inflicted?
- How many suspects were there?

BPA is extremely important because it tells us a chronicle of what may have happened at a crime scene. It also is able to reveal what did not occur, which can potentially eliminate people from a pool of suspects. Our focus within this chapter will concentrate on basic terms surrounding blood patterns, surface texture, drop height, direction of travel, angle of impact, types of blood stains, other common patterns found at crime scenes, area of origin versus area of convergence, evidence collection, and crime scene reconstruction.

Blood Stain Basics

Blood **spatter** is a scattering of bloodstains that vary in size and may be produced by numerous methods. The **origin** is the area from which the blood originated from and the surface a stain lands on is called its **target surface**. The shape can be changed due to factors such as the velocity, the angle in which it hit the surface, the type of surface it lands on, and how far the stain traveled. The original drop that hits a surface is known as the **parent drop**. The drop may not necessarily form a perfect circle due to the factors described above. If this occurs, the drop may be somewhat irregular with pointed edges that radiate outward from the original stain. These edges are known as **spines**. Some spatter may ultimately become completely dislodged from the parent drop, which is known as a **satellite**.



Surface Texture

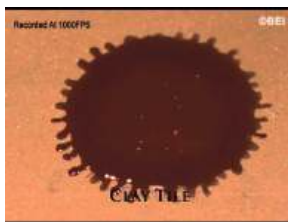
The surface on which the stain lands on may help to impart certain characteristics within a blood stain. The more solid and impermeable the surface, the less spatter will be found. For example, if a blood drop hits a steel beam or lands on a piece of glass, it will appear as an intact stain. This is due to blood's **cohesive** properties, or the attractive force of blood to itself and its **surface tension**, which is the ability of blood to stick to itself. If a blood drop lands on a permeable surface, this will impart a drop that contains an abundant amount of spatter. The blood fills the holes of the permeable surface and once contact is made, blood will be expelled back to create the spatter. Examples of permeable surfaces are cardboard, clothing, or bed sheets.



Stain seen on glass (stain is intact, no spatter)



Stain seen on paper (spatter)



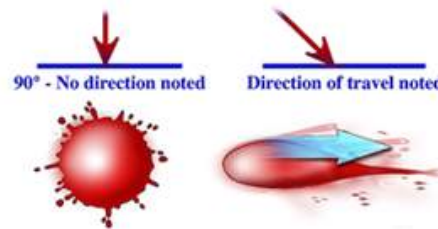
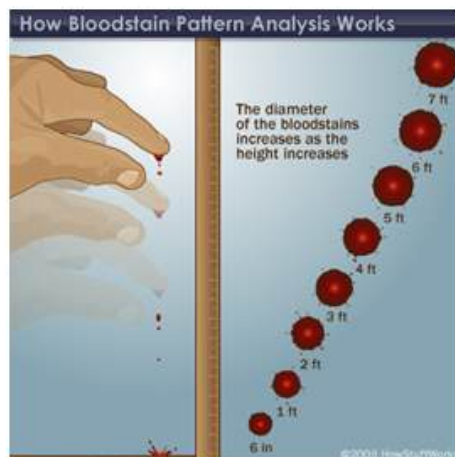
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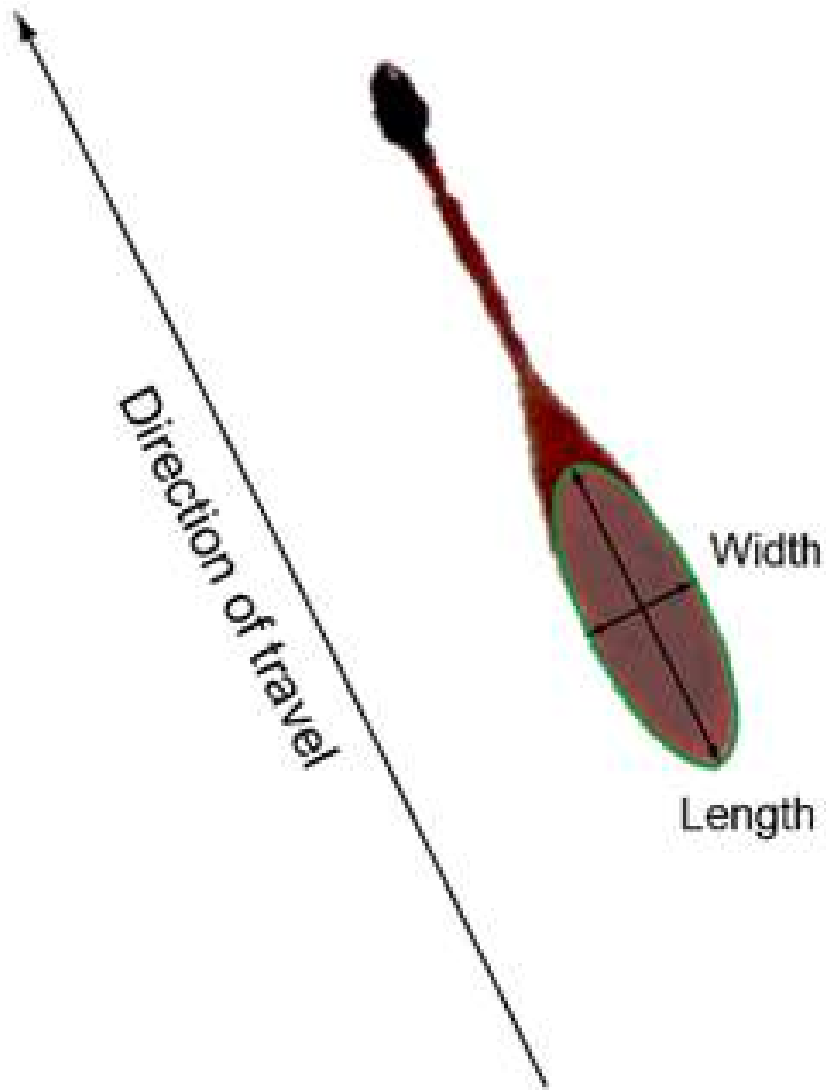
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Height

A stain may reveal an abundant amount of information. The closer a stain is to its target surface, the smaller the stain will be. If more distance is applied from the target surface, the stain will begin to expand, or get larger.



The direction that a stain is traveling can be clarified by studying the stain's shape. There is a general misnomer of how to determine the direction. The general public for example, may interpret the following stain as traveling southeast. A person educated in the fundamentals of forensic science will know that the tail always points in the direction of travel of a stain. Hence, the stain below is actually travelling northwest.



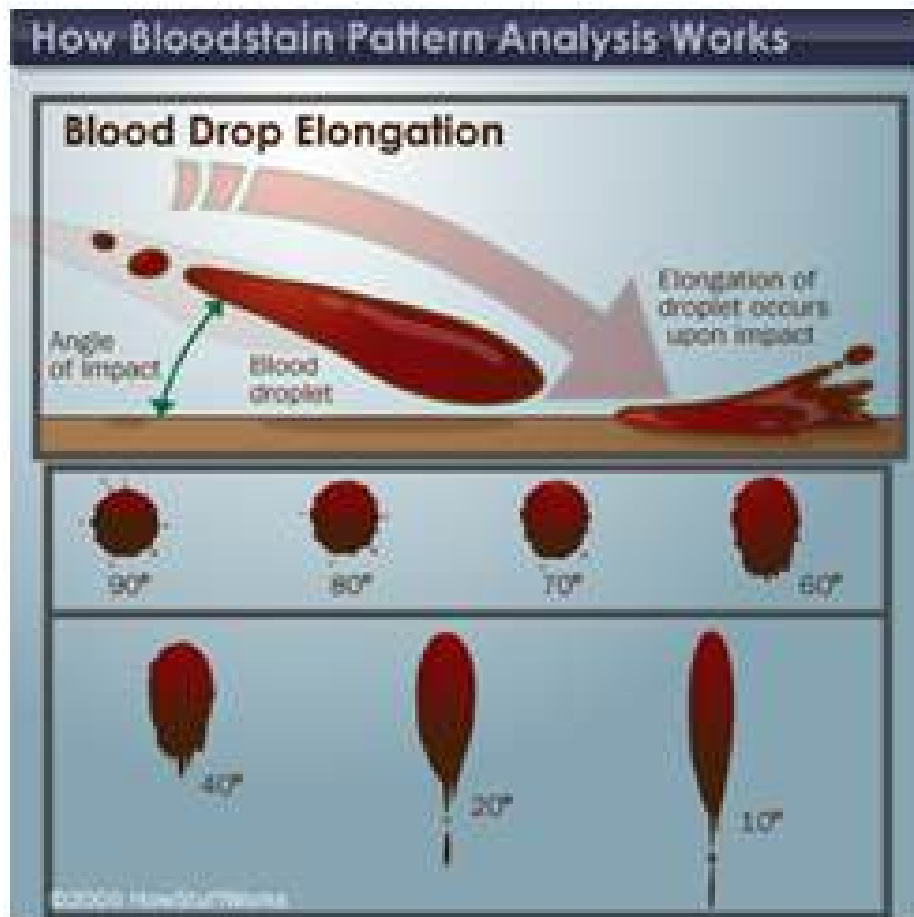
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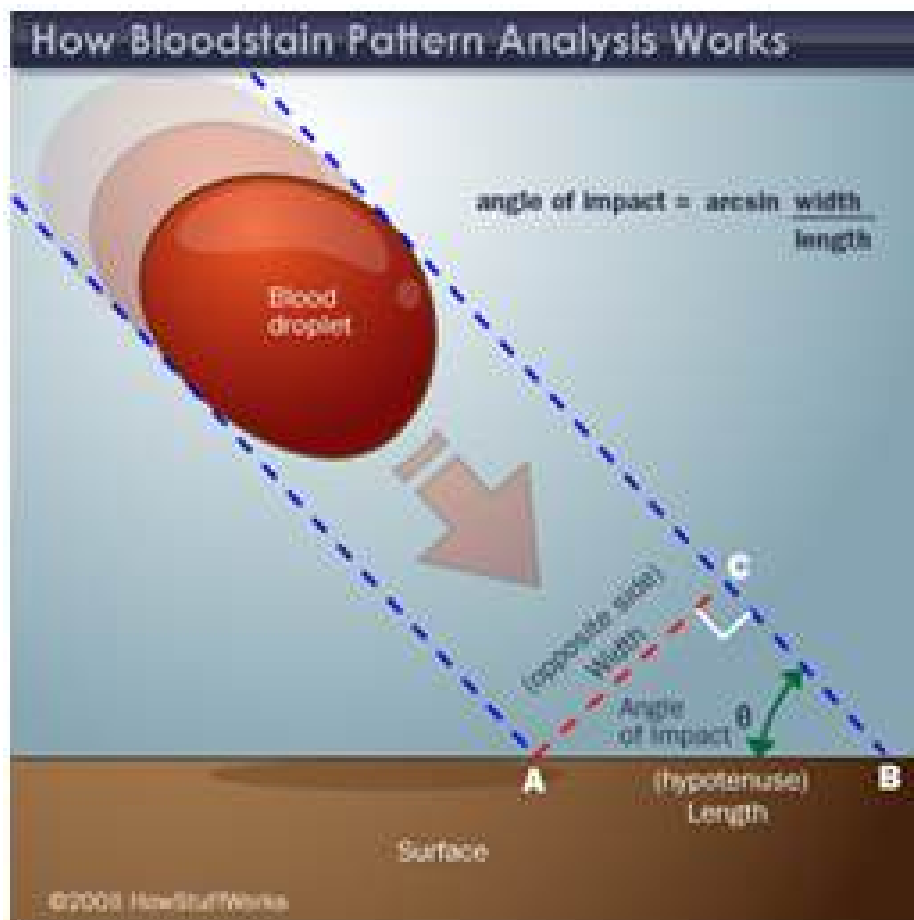
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Angle of Impact

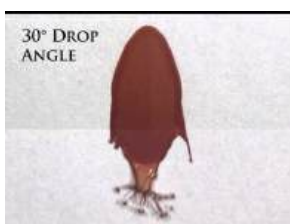
When a drop falls at 90° , it forms a perfect circle. Any angle less than 90° will change the stain to a more elliptical shape. The closer a stain falls to a 90° , the more circular the stain will be. Vice versa, the further away from 90° , the more elliptical or elongated the stain will be. These stains may also have tails or spines that drip downward from the original parent drop due to gravity.



The angle of impact may be calculated (using a scientific calculator) using a trigonometric function. The first step is to measure the width and length of the stain in millimeters, then divide the width of the stain by its length. The next step is to take that answer and calculate the arcsin which will provide a whole number followed by a decimal. This answer will be rounded to the nearest whole number to determine the degree at which the stain came in contact with its target surface.



For example, let's say that the width of a stain is 15 mm and its length is 35 mm. 15 is divided by 35 and the answer will yield 0.42857. With the answer of 0.42857 still on the calculator's screen, depending on the calculator, shift sin, or 2nd sin will be pressed. This will produce an answer of 25.37693. This number is rounded to the nearest whole number, which is 25. Therefore, the blood stain hit the target surface at an angle of 25°.



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Types of Blood Stains

Bloodstains are grouped as **passive**, **transfer** and **projected/impact**. **Passive stains** are caused by gravity. Some examples of passive stains are drip stains/drip patterns/drip trail patterns, flows, pools, and saturation stains.

Drip stains are caused by a falling drop that is simply caused by the natural source of gravity. Drip stains that fall at a 90° angle may or may not have spines depending on the surface the drop lands on. If the drop contains spines, they will be attached to the parent drop and evenly dispersed around the entire drop. They relatively will also be the same size all around. **Drip patterns** are caused by a drop of blood, or multiple drops falling on top of another drop. This propels satellites to be dispersed around the initial drop of blood. The more drops that fall onto the initial parent drop, the more satellites will be seen.

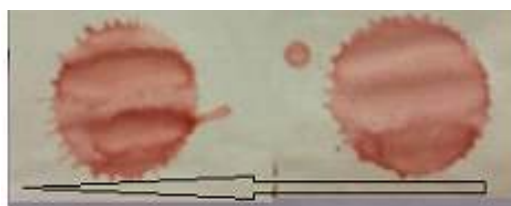


Drip Stain



Drip Pattern

Drip trail patterns are also caused by gravity. Blood may drop off of a weapon, person, or a bloody site. The stains leave a trail which may indicate the movement of the suspect after they have inflicted the injury, or they may also tell a story about where the victim headed after receiving the injuries. Here, the drops will have more spines on one side of the parent drop versus the other. This helps to tell the direction the person was traveling. **Flow patterns** are caused by the movement of blood on a surface due to gravity. Flows usually travel downward and can run off a surface.



Drip trail pattern



Flow Pattern in an arterial spurt

Pools are simply an accumulation of blood in a particular spot. They are usually deposited on a flat surface and are left undisturbed. Pools on a flat, nonabsorbent surface may take a considerable amount of time to dry. If the stain has accumulated on an absorbent material, it may spread and take a shorter amount of time to dry. The stain may also appear to be larger than it originally was due to the absorbency of the porous material. This type of stain is identified as a **saturation stain**.



Pool



Saturation stain

Transfer stains are created when a bloody object comes in contact with another surface and leaves a resulting impression. These stains will initially start dark and will diminish in color and amount of blood as the transfer progresses. Wipes, swipes or patterns such as a bloody handprint or shoeprint are examples of transfer stains.



Wipes can be created by an object that moves through a surface that already has blood on it. It will ultimately change the appearance of the primary stain. The direction of the stain can be noted, as seen by the circular pattern left in the stain. **Swipes** are created when a bloody object comes into contact with a non-bloody surface, leaving a resulting stain. The feathering on the stain indicates the relative motion made when the stain was created. In this picture, heavier blood is seen on the right and as the stain progresses to the left, the stain grows fainter.



Spatter may be classified as a **projected stain**, which is caused by blood being under pressure (a force is applied) and results in it striking a surface. The blood can be under pressure within the body, which will cause stains such as arterial spurting and expiration stains. The pressure may also be caused externally as seen in cast-off stains.

Arterial spurts are caused by blood exiting an artery under pressure. The blood pressure causes the blood to be expressed from the body each time the heart beats. If the blood has hit a wall, flow will also be evident as gravity will pull the stain downward. The resulting stain will also be bright red because the blood present in the artery is oxygenated. Satellite stains may also be apparent due to the impact of the stain.



An **expiration stain** results from blood forced by air out of the nose, mouth, or a wound. Expiration stains may vary in appearance due to the amount of pressure applied to the resulting blood stain and due to the blood being diluted by saliva. High amounts of pressure will produce almost mist-like droplets whereas low pressure will create larger stains with long tails.



In **cast-off stains**, the pattern results from blood drops released from an object due to it being in motion. For example, a person may swing a bloody knife to repeatedly stab another individual. This will cause an arc of small blood droplets to be scattered onto a nearby surface, such as a wall. The tails on these stains will indicate the direction in which the weapon traveled. The pattern may also indicate whether the person inflicting the wounds is right- or left-handed based on the backward thrust. The direction of the blow will be in one direction, as the direction of the backward thrust will appear in the opposite direction. These stains may also tell how many blows a person received. An investigator needs to count the forward and backward patterns and add one to the total count. The reason that one is added is because the first blow will not cause cast off patterns. Once blood is exposed, the remaining blows will cause the blood to be dispersed into each of the corresponding arcs.



Impact spatter is created when a force is applied to blood. The spatter will depend on the force applied along with the speed in which it exits the body. The different amounts of speed are low-, medium- and high-velocity impact spatters.

Low-velocity impact spatter (LVIS) is a force of energy equal to gravity and may increase to a force or energy of 5 ft/s. These stains may be caused by blood dripping from an open wound. The stain produced is fairly large and may be 4-5 mm in diameter.



Medium-velocity impact spatter (MVIS) is caused when a force of energy from five to twenty-five feet per second is applied to blood. These type stains are produced from beatings, stabbings or secondary spatter. The stains range from 1 up to 3 mm in diameter.



High-velocity impact spatter (HVIS) is created when a force of energy of a velocity greater than 100 ft/s is applied to blood. These stains are related to gunshot wounds, explosions, or high speed automobile accidents. The stain will be quite small and is 1 mm in diameter or less. The stains usually appear mist-like.



Other Types of Stains

Sometimes, a drop or pool of blood will be left undisturbed just long enough for it to start to dry. If a stain has existed on a surface for a short amount of time, and then the stain is altered, it may leave what is called a **skeletonized stain**. It still has the characteristics of the original stain along with the changes made. This stain may also be called a perimeter stain.

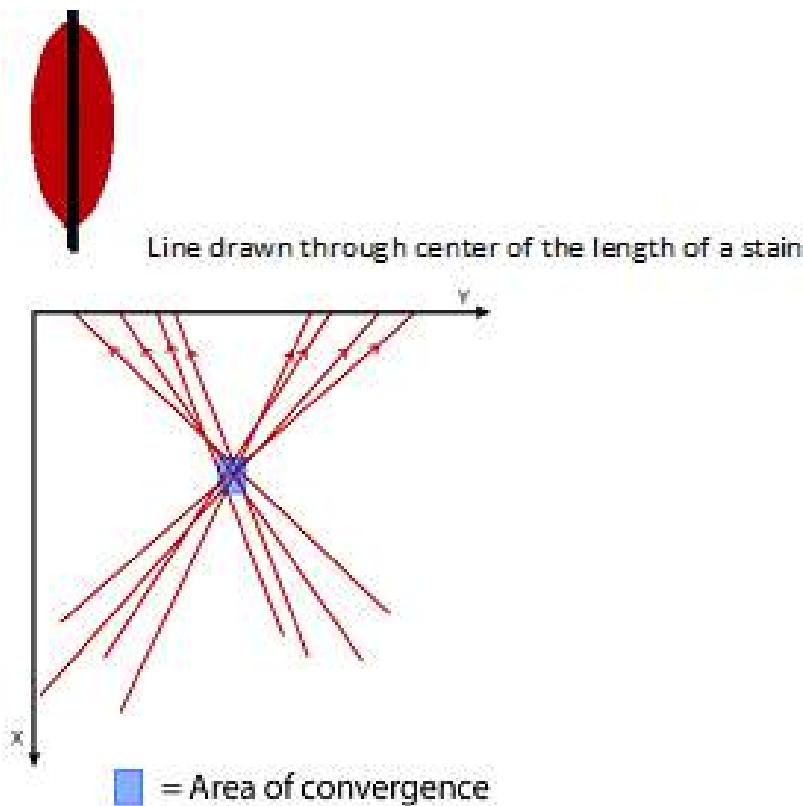


When blood is spattered onto a target surface and an object blocks some of the spatter, a **void pattern** is created. In that instance, the blood is deposited onto the person or object instead of hitting the target surface. This creates an absence of blood and the pattern may be able to illustrate where the person was standing when injury was inflicted, or may reveal an object that could be missing from the crime scene.



Area of Convergence and Area of Origin

The **area of convergence** can be ascertained by looking closely at individual blood stains within blood spatter. A line is drawn through the length of a blood stain, right through the centermost point of the stain. The lines of the stains will intersect, and that is where the area of convergence is located. This area reveals the location of the blood source in 2D, e.g. the height in which the event took place. Although it is not an exact location, it does provide a general idea of where blood source was located.



To determine the area of origin, impact angles of those drops used to determine the area of convergence are calculated. The width and length are measured, the width is then divided by the length, and then the arcsin is taken to produce the actual angle in which that specific blood drop hit the surface. Stringing will be the next item at hand. An investigator attaches a string to the blood drop and with a protractor, measures the angle of impact and places that string onto a stationary item, such as a pole. Once all drops have been calculated and have gone through the stringing method, the **area of origin** or **point of origin** is disclosed. This will specify where the victim was located at the time of the incident in three dimensions. There are some programs available to help reveal the point of origin. These software programs are BackTrack and HemoSpat.



Evidence Documentation and Collection

One of the most important things an investigator must do is to secure the crime scene. Once it has been secured, the investigator walks through and assesses the scene. Evidence markers are used to tag the evidence and to help keep everything organized as the investigation takes place. If blood spatter has been identified on a large immovable object, multiple photographs must be taken. Close-ups are taken with a small ruler placed next to individual stains to illustrate the relative size. If photographs are taken of an entire blood spatter, not just individual drops, large rulers are placed around the perimeter of the spatter. Smaller rulers may also be placed inside the perimeter next to individual stains to confirm size. This is called the **perimeter ruler method**. Another method can be used called a **grid method** in which grids are set up in measured increments before photographs are taken of the blood spatter. Pictures are also taken of the entire crime scene to show where the blood was located in relation to the scene.



Evidence markers



Close-up with
a small ruler



Perimeter ruler method

If the object on which the blood stain is present can be sent into the lab entirely or cut out, the entire stain should be sent after photographing it. It is important that the stain is allowed to air dry before it is placed in a package. Blood evidence should always be packaged in a paper bag versus a plastic bag. This helps to ensure that the object will dry completely in a paper bag versus staying wet in a plastic bag, which can produce mold that can destroy vital evidence.

Along with the photographs, an investigator may take additional notes and sketch the area to help document the site. Many have been known to walk the scene as they use a video recorder to take visuals and narrate what they see as they walk through the entire area.

All samples need to be labeled on the container that will be submitted for analysis and documented into the chain of custody to prove that they have been handled correctly and have been in the minimum amount of hands possible. Blood samples will need to be collected with sterile swabs from separate areas of the scene and sent to the lab. With this evidence at hand, the lab staff will run a DNA profile to see if all of the blood found was from the victim. If not, there is a strong indication that the suspect could have been wounded through the struggle and left some of his/her blood behind as well.

Crime Scene Reconstruction



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Crime scene reconstruction is executed to demonstrate what events could have occurred at a crime scene based on the evidence found and any eyewitness statements obtained. Usually, a blood spatter expert/analyst, forensic pathologist, or trained law enforcement may be involved in reproducing the events. Eventually, the goal is to place oneself into the victim's or suspect's shoes to explain affairs such as how tools were used to inflict injury, how the stains were produced, the number of suspects, the position of victim to that of the suspect, etc. All of this information may correlate the victim, assailants and the actual location in which this crime took place in a way that may help prove to the jury the events that occurred despite of what the defense attorney tries to say to delineate the guilt from his/her client.



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Chapter Summary

- Bloodstain pattern analysis (BPA) is the examination and analysis of bloodstains left behind at a crime scene and the interpretation of how those stains are produced.
- The original drop that hits a surface is known as the parent drop. The drop may be somewhat irregular with pointed edges that radiate outward from the original stain, which are known as spines. Some spatter may ultimately become completely dislodged from the parent drop, which is known as a satellite.
- The more solid and impermeable the surface, the less spatter will be found. If a blood drop lands on a permeable surface, this will impart a drop that contains an abundant amount of spatter.
- The closer a stain is to its target surface, the smaller the stain will be. If more distance is applied from the target surface, the stain will begin to expand, or get larger.
- The tail of a blood stain always points in the direction of travel of a stain.
- The closer a stain falls to a 90°, the more circular the stain will be. Vice versa, the further away from 90°, the more elliptical or elongated the stain will be.
- The angle of impact = $\arcsin(\text{width}/\text{length})$
- Bloodstains are grouped as passive, transfer and projected/impact.
- Passive stains are caused by gravity. Some examples of passive stains are drip stains/drip patterns/drip trail patterns, flows, pools, and saturation stains.
- Drip stains are caused by a falling drop that is simply caused by the natural source of gravity.
- Drip patterns are caused by a drop of blood, or multiple drops falling on top of another drop.
- Drip trail patterns may be created by blood dropping off of a weapon, person, or a bloody site. The stains leave a trail which may indicate the movement of the suspect or victim.
- Flow patterns are caused by the movement of blood downward on a surface due to gravity.

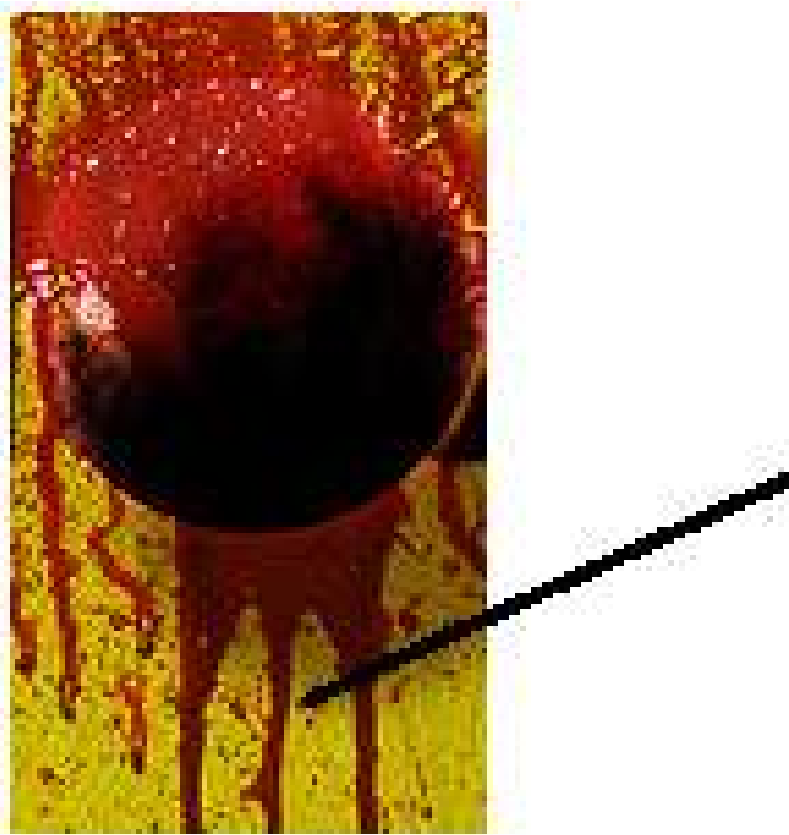
- Pools are simply an accumulation of blood on a flat surface and are left undisturbed.
- If the stain has accumulated on an absorbent material, it may spread and take a shorter amount of time to dry. The stain may also appear to be larger than it originally was due to the absorbency of the porous material. This type of stain is identified as a saturation stain.
- Transfer stains are created when a bloody object comes in contact with another surface and leaves a resulting impression. Wipes, swipes or patterns such as a bloody handprint or shoeprint are examples of transfer stains.
- Wipes may be created by an object that moves through a surface that already has blood on it, changing the appearance of the primary stain.
- Swipes are created when a bloody object comes into contact with a non-bloody surface, leaving a resulting stain.
- Spatter can be classified as a projected stain, which is caused by blood being under pressure (a force is applied) and results in it striking a surface. Examples of projected stains are arterial spurting, expiration stains, and cast-off stains.
- Arterial spurts are caused by blood exiting an artery under pressure.
- An expiration stain results from blood forced by air out of the nose, mouth, or a wound.
- In cast-off stains, the pattern results from blood drops released from an object due to it being swung in a particular motion.
- Impact spatter is created when a force is applied to blood. The different types of impact spatter are low-, medium- and high-velocity impact spatters.
- Low-velocity impact spatter (LVIS) is a force of energy equal to gravity and may increase to a force or energy of 5 ft/s. They are caused by blood dripping from an open wound and may be 4-5 mm in diameter.
- Medium-velocity impact spatter (MVIS) is caused when a force of energy from five to twenty-five feet per second is applied to blood. They are produced from beatings, stabbings or secondary spatter, and range from 1 up to 3 mm in diameter.
- High-velocity impact spatter (HVIS) is created when a force of energy of a velocity greater than 100 ft/s is applied to blood. These stains are related to gunshot wounds, explosions, or high speed automobile accidents and may be 1 mm or less in diameter.
- Two other types of stains may not necessarily fall in any of the other categories, but that does not make them any less important.
- If a stain has existed on a surface for a short amount of time, and then the stain is altered, it may leave what is called a skeletonized stain.
- When blood is spattered onto a target surface and an object blocks some of the spatter, a void pattern is created.
- The area of convergence can be ascertained by looking closely at individual blood stains within blood spatter. A line is drawn through the length of a blood stain, right through the centermost point of the stain. The lines of the stains will intersect, and that is where the area of convergence is located.
- An investigator attaches a string to the blood drop and with a protractor, measures the angle of impact and places that string onto a stationary item, such as a pole. Once all drops have been calculated and have gone through the stringing method, the area of origin or point of origin is disclosed. This will specify where the victim was located at the time of the incident in three dimensions.
- One of the most important things an investigator must do is to secure the crime scene. Once it has been secured, the investigator walks through and assesses the scene. Photographs are taken, sketches are made and detailed notes are taken.
- Proper protocols are followed to ensure that all evidence is collected and packaged correctly.
- All samples need to be labeled on the container and then documented into the chain of custody to prove that they have been handled correctly and have been in the minimum amount of hands possible.
- Crime scene reconstruction is executed to demonstrate what events could have occurred at a crime scene based on the evidence found and any eyewitness statements obtained.

Review questions

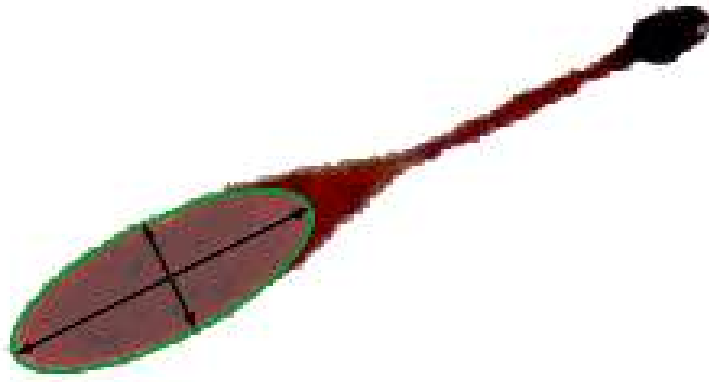
1. What is a reason behind why these stains showed below are irregularly shaped and have spines?



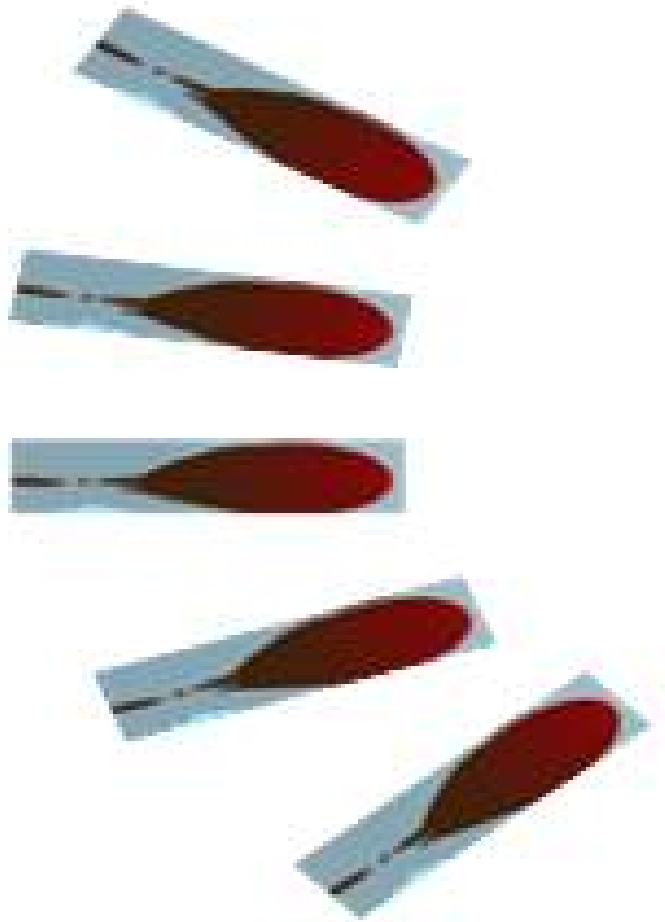
2. Paying attention to the part of the blood stain emphasized, would this type of stain be categorized as a passive, transfer, or projected stain? Under this category, which type of stain is shown here?



3. Calculate the impact angle of the stain below.



4. In which direction is the stain shown on question 3 traveling?
5. Is there a direct or inverse relationship between the angle from which blood is dropped and the shape of the stain? Explain.
6. How might a HVIS blood stain be recreated in a laboratory for further analysis?
7. Which methods are used to determine the area of origin? Explain how these methods are used in order to determine where the victim was located when they received injury.
8. An investigator arrives at a homicide. He walks through and assesses the scene and discovers blood spatter along with a body. After the initial walk through, he secures the area. Evidence markers are then placed on the evidence that is found. Pictures of the blood samples are taken. Close-ups of small stains are taken and photos are taken of the large blood spatter with large rulers placed around the perimeter of the spatter. Photographs are then taken of the entire crime scene. What was the initial mistake the investigator made when arriving at the crime scene?
9. What other mistake is noted from the scenario above?



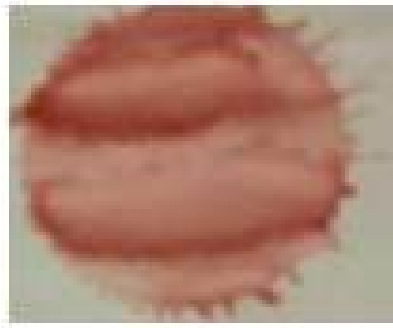
10. Determine the area of convergence for the blood stains pictured above.

11. True or False: Wipes are created when a bloody object comes into contact with a non-bloody surface, leaving a resulting stain. Swipes can be created by an object that moves through a surface that already has blood on it.

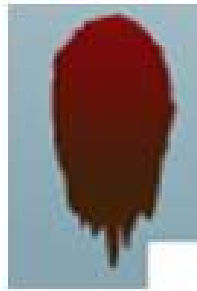
12. True or False: An investigator needs to count the forward and backward patterns and add one from a cast-off stain to determine the number of blows the victim received.

13. True or False: As the height from which a blood stain falls from increases, the size of the drop decreases.

14. True or False: As the velocity and force of a drop increases, the size of the blood droplets will decrease.



15. True or False: This stain above is known as a drip trail pattern and the direction in which the person is traveling is east.

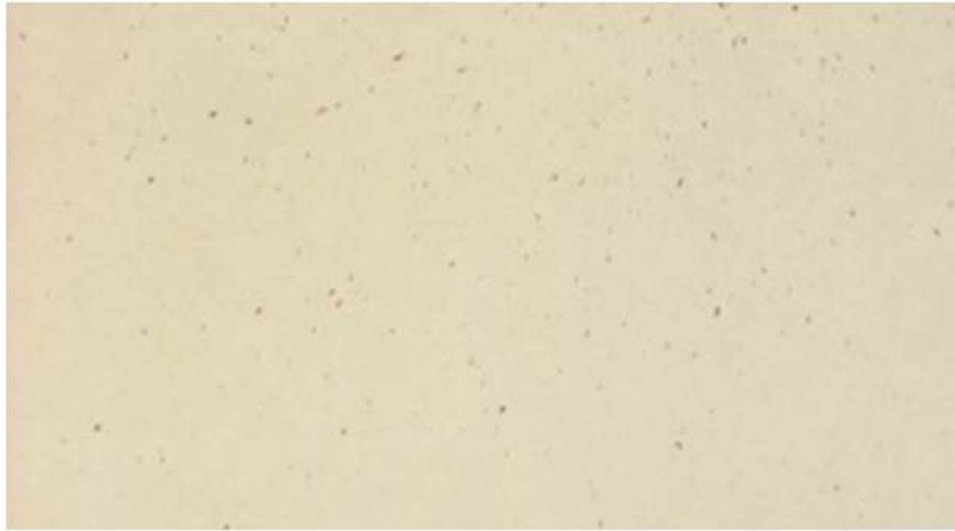


16. At which angle would you presume this blood stain above hit the surface?

- A. 90
- B. 20
- C. 70
- D. 40

17. How may expired blood be differentiated from other blood stains?

- A. The stain will be bright red because the blood is oxygenated.
- B. The stain is less concentrated and the color may appear more subtle than other stains.
- C. The feathering on the stain identifies the stain as being expired from the mouth, nose, or wound.
- D. The stain is fairly large and ranges from 4-5 mm in diameter.



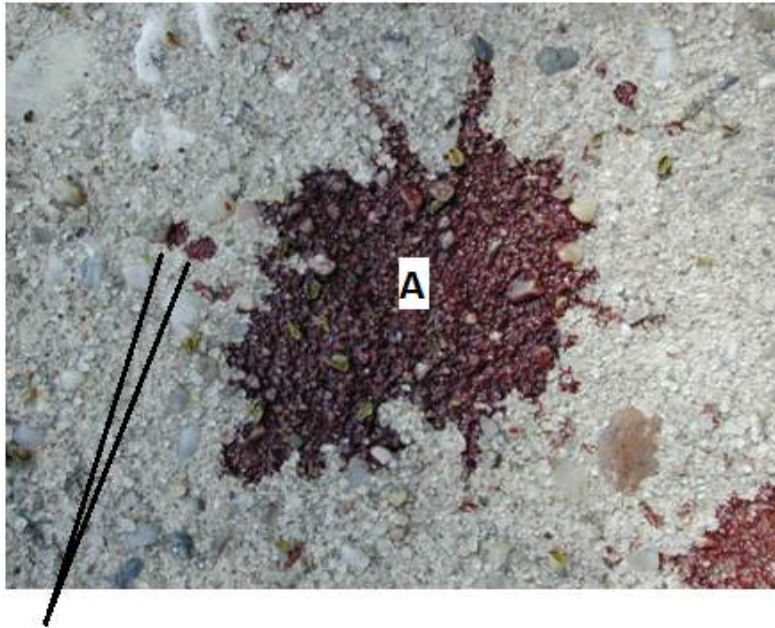
18. Which type of blood stain is represented in the picture shown above?

- A. Cast-off
- B. HVIS
- C. MVIS
- D. Arterial spurt



19. What information may be obtained by examining the stain shown above?

- A. The stain fell from a 90° angle and landed on a nonporous surface.
- B. The stain fell from a 30° angle and landed on a porous surface.
- C. The stain fell from a 50° angle and landed on a nonporous surface.
- D. The stain fell from a 60° angle and landed on a porous surface.



20. The stain labeled A above is known as a parent drop. What are the two stains called that are completely detached from the original stain?

- A. Spatter
- B. Spines
- C. Drips
- D. Satellites

Educational Links for Further Understanding

- Types of stains: https://www.youtube.com/watch?v=zjfdpenl1Rc&oref=https%3A%2F%2Fwww.youtube.com%2Fwatch%3Fv%3Dzjfdpenl1Rc&has_verified=1
- Area of convergence and area of origin: <https://www.youtube.com/watch?v=3jFKZaSeNjg>

Unit 6 Blood

CONCEPT

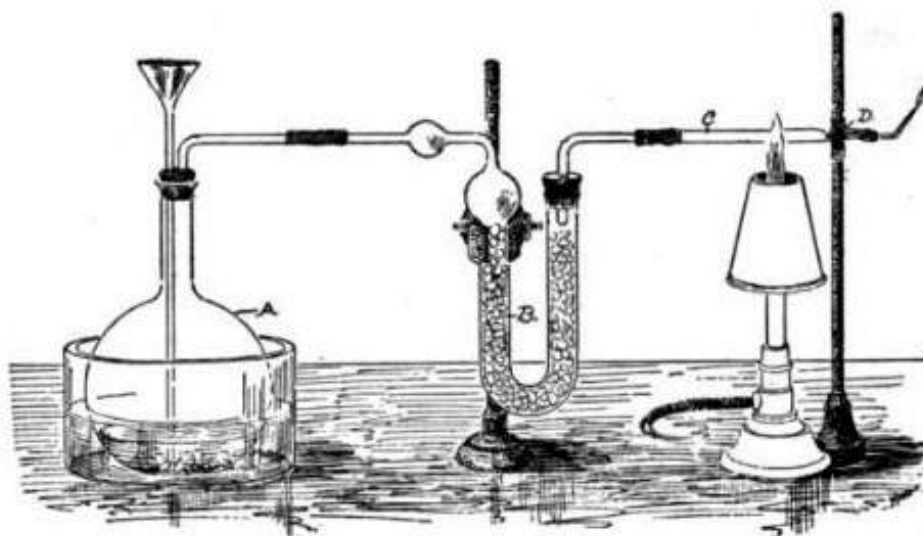
9

Unit 7 Drugs & Toxicology

Unit 7 Drugs Toxicology

TEKS:

- Distinguish between physical and chemical properties of matter using the periodic table. [6B]
- Determine the elements within a compound or mixture. [6C]
- Identify the four types of chemical reactions. [6D]
- Explain properties of refractive index. [6E]
- Explain dispersion of light through a prism. [6F]
- Identify the light sources used in forensic science such as ultraviolet light. [6G]
- Explain the examination of trace evidence using instruments such as a spectrophotometer, stereoscope, electron microscope, and compound microscope. [6H]
- Perform continuous and light emissions laboratory procedures to identify trace evidence. [7A]
- Explain the absorption, distribution, and elimination of alcohol through the human body. [10A]
- Describe the blood alcohol laboratory procedures as they relate to blood alcohol concentration. [10B]
- Explain the levels of tolerance and impairment due to alcohol consumption. [10C]
- Explain the precautions necessary in the forensic laboratory for proper preservation of blood samples. [10D]
- Classify controlled substances using Food and Drug Administration classification. [13A]
- Identify controlled substances using laboratory procedures such as color test reactions, microcrystalline procedures, chromatography, and spectrophotometry. [13B]

**Introduction**

Toxicology is the branch of science that deals with the toxins found in accidental, homicidal, and suicidal poisonings as well as a drug overdose. Therefore the role of a forensic toxicologist is vital in our society. They must be able to detect and identify drugs and toxins that may be present in a victim's body. Forensic toxicologists are an integral part of a forensic investigative team and may be found working as forensic technicians in crime labs and as medical examiners in the medical field or the morgue. A controlled substance or "drug" may have a different meaning depending on how it is used by them. As far as it pertains to forensics a controlled substance is any drug that is regulated by the federal government such as medications or illicitly used drugs.

Objectives

- The student will be able to:
- Analyze toxicological evidence collected from a crime scene.
- Identify proper collection and preservation methods for drug evidence.
- Identify and explore toxicology lab procedures.
- Understand the methods of screening and confirmation tests for drugs.
- Compare the types of drug dependence.
- Characterize types of drugs.

Toxicology

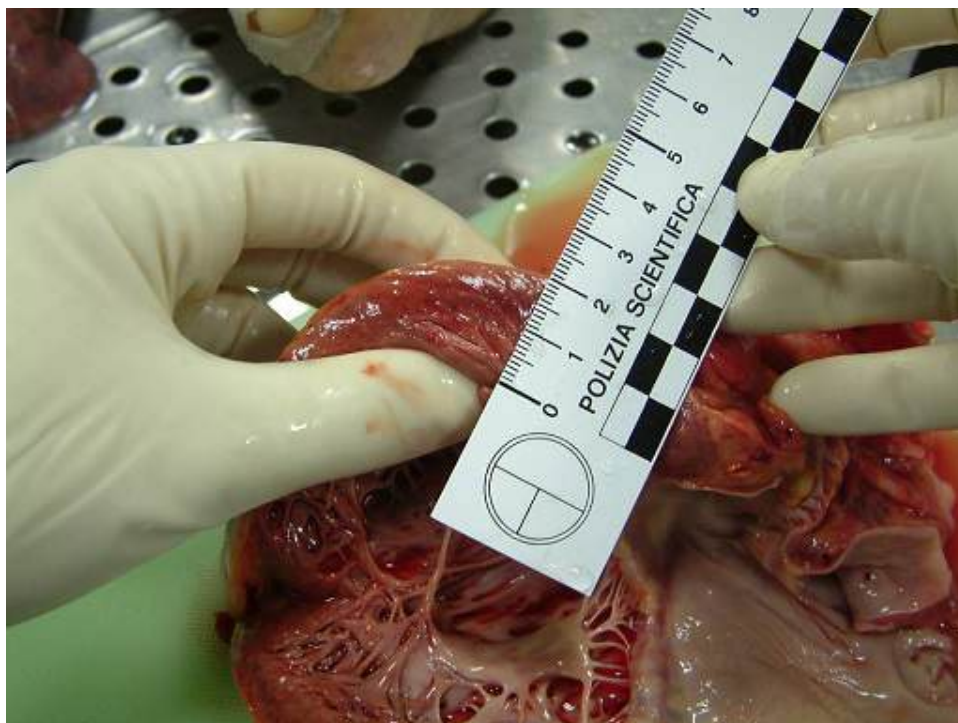


Forensic Toxicologist

Toxicology is the study of drugs (natural or synthetic) and poisons, and their effects on the body. A forensic toxicology uses toxicology and pharmacology as well as other science disciplines to perform an investigation into either a death, poisoning, and or apparent drug abuse. Examples may include but are not limited to testing for drug use or abuse in the workplace or for performance enhancing drugs in athletic events or organizations. Also forensic toxicology is an important step when performing a postmortem examination.

Role of the Toxicologist

A forensic toxicologist is a scientist or medical professional who specializes in the study of the symptoms, mechanisms, treatments and detection of toxins that may or has poisoned an individual. This includes the study of bodily fluids, tissue, and organs for drugs and or poisons in a postmortem pathological examination and or examination of a crime scene for toxicological evidence. The forensic toxicologist must also determine if the level of toxicity of the drugs or poison found in the postmortem examination was enough to kill the victim. Toxicity depends on the amount of toxic substance and the mass of the organism. All substances are toxic in large enough doses, even sugar and water. The lethal dose (LD50) of a substance is expressed as a ratio between a certain mass of the substance and 1 kilogram of the body mass of an organism exposed to the substance (mg/kg). It is important to note that the smaller the lethal dose, or LD50, the more potentially dangerous a substance is.



Collecting and Preserving Toxicological Evidence

The medical examiner will collect the specimens needed to perform a toxicological test postmortem or “en vivo” if the victim or suspect is alive. An example of the specimen’s collected would be like blood, urine, and stomach chime. The specimens are then properly identified and sealed in order to maintain the proper protocol for chain of custody. All packages must prevent loss and cross-contamination of evidence. If it is a volatile solvent, like a gas or glue used for “sniffing” it must be in an airtight container to prevent evaporation.



Techniques used in the Analysis of Controlled Substances and Toxins

The simplest method to test for drugs is to do a screening test which is used to reduce the number of possible identities of an unknown substance. One way to screen for drugs or toxins is to find their pH, the pH scale measures

how acidic or basic a substance is, and because all drugs and poisons are made up of type of chemical it is therefore either basic or acidic. The pH scale ranges from 0 to 14, where a pH of 7 is neutral. A pH less than 7 is acidic and a pH greater than 7 is basic.

When forensic toxicologists want to specifically identify a substance they use a wide variety of Conformity tests. For example Color tests, Micro-Crystalline test, Chromatography tests, Gas Chromatography (GC), High Performance Liquid Chromatography (HPLC), Spectroscopy, and Mass Spectroscopy.

Color tests are used to yield specific individual characteristics of colors in certain drugs when mixed with certain chemicals.



- Marquis Reagent turns purple with heroin, morphine, and most opium derivatives; it turns orange/brown with amphetamines and methamphetamines
- Dillie-Koppanyi reagent is used as a simple spot-test to identify barbiturates , it turns violet-blue with barbiturates



- Duquenois-Levine reagent is used in the Duquenois-Levine test, an established screening test that turns purple with marijuana and chloroform.
- Van Urk reagent turns blue-purple when in the presence of LSD
- Scott Test uses a reagent that turns blue with cocaine

Microcrystalline Test identifies a substance based on the color and shape of crystals formed when the substance is mixed with specific reagents.

Chromatography is used to separate complex mixtures into specific components by attraction to a stationary phase while being propelled by a moving phase.

- Thin Layer Chromatography uses a solid stationary phase and a moving liquid phase; can be used to compare an unknown sample with known samples.
- Gas Chromatography uses a stationary liquid phase and a moving gas phase (called a carrier gas) which flows through a stainless steel or glass column, where the components separate by moving through the column at different rates. The retention time is how long it takes for a component to emerge from the column; the retention times of known and unknown substances can be compared.
- High-performance liquid chromatography (HPLC) is used to separate the components in a mixture, to identify each component, and to quantify each component, therefore identifying the specific components of a certain drug.

Spectrophotometry exposes substances to electromagnetic radiation.

- UV and Visible Spectrophotometry measures and records absorbance of UV and visible light as a function of wavelength or frequency.
- Infrared Spectrophotometry is similar to UV, but because absorption bands are so numerous, it is far more capable of identifying a substance specifically.

Mass spectrometry is an analytical technique in chemistry that identifies the amount and type of chemicals present in a sample by measuring the mass-to-charge ratio and abundance of gas-phase ions. A mixture's components are first separated with gas chromatography which is sensitive to minute amounts. With the data obtained from gas chromatography and mass spectrometry, an analyst can separate components of a complex drug mixture and identify each substance present.



Toxicological Analysis of Alcohol

A field sobriety test is a preliminary test performed to ascertain the degree of a suspect's physical impairment, and whether further tests are justified like a breath or blood test. The field sobriety test includes a horizontal-gaze nystagmus test, walk and turn in a straight line test, a one-leg stand, and a preliminary breath test performed by a hand held breathalyzer. To figure out how much or if alcohol has been consumed either a breath or blood test can be performed on the suspect. In a breath test a breathalyzer is used to measure alcohol content deep within the lungs (alveoli). A blood test is performed by taking a sample of blood and analyzing it using gas chromatography which separates the alcohol from any other chemicals that may be found in the blood.



When detecting drugs in the body of a living individual it is important to note that most drugs will start to dissipate from the blood stream after 24 hours and urine in about 72 hours. Therefore it is better to test for drugs in the individual's hair. This is because drugs can be found entrapped in the keratin protein found in hair. As hair grows,

the drug's location on the hair shaft becomes a marker for the time of drug intake. One drawback from this is that some drugs may enter a hair's surface from environmental exposure or sweat. This can cause a problem with the accuracy of the test.

Individuals thought to have been poisoned by compounds suspected of containing a heavy metal are analyzed by destroying the organic matrix through chemical or thermal oxidation, leaving only the metal to be identified. The heavy metal can be then detected using such methods as the Reinsch test, emission spectroscopy, and or X-ray diffraction. Unfortunately, while this identifies the metals present it removes the original compound from which it was derived, therefore hindering efforts to determine what may have been ingested. The toxic effects of various metallic compounds can vary considerably and may act as natural causes. For example the heavy metal arsenic which can mimic heart disease or a stroke and mercury which may look like dementia since it does damage to the brain as well as other vital organs.



Controlled Substance (Drugs)

Drug Dependence

According to the Food, Drug, and Cosmetic Act, a drug is a substance intended for use in the diagnosis, cure, mitigation, treatment, or prevention of disease. Although it is often used illicitly as a substance that many individuals take for pleasure, but which can cause addiction, habituation, and or a marked change in consciousness. Any drug prescribed by a doctor with a prescription is considered a **controlled substance**.

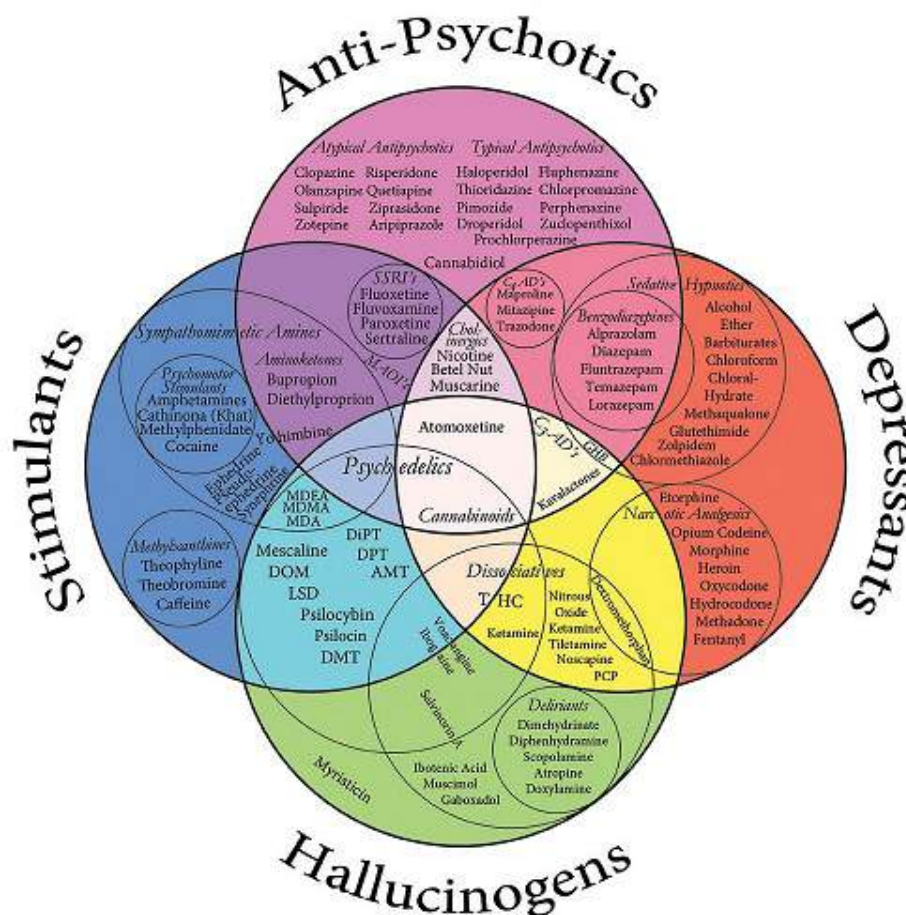
Drug dependency is a result from an individuals need for escape or pleasure caused by underlying emotional and or

psychological needs. As a result the desire for both emotional and physical well-being in the eyes of the user is the main motive leading to repeated drug abuse. The user will become withdrawn from society and eventually neglect their individual and social responsibilities.

Individuals that use controlled substances legally through a prescription or illegally may grow a dependency on that drug. There are two types of dependencies that will be covered; **psychological** and **physical**.

Psychological dependence involves emotional–motivational withdrawal symptoms, like depression, anxiety, and mood swings to name a few after stopping the use of the drug.

Physical dependence refers to the bodies' reaction to prolonged use or abuse of a drug resulting to the building of tolerance in the body making it ineffectiveness. This leads to negative symptoms stemming from the body craving of the drug due to abrupt discontinuation or dosage reduction.



Types of Drugs

Most drugs fit into one or more of the following categories Narcotics, Hallucinogens, Depressants, and Stimulants. Although there are some drug categories that can show likeness to more than one of the other categories.



- A **Narcotic** is a drug that induces sleep and depresses vital body functions such as blood pressure, pulse, and breathing. There is a misconception when it comes to narcotics being classified as another name for an illicit controlled substance or drug. The main type of narcotic comes from the family of opioid analgesic alkaloids found in the opium poppy plant also referred to as opiates. Within the classification of opioid, one would find heroin, morphine and codeine. These drugs are considered analgesics; they are used to lessen or eliminate pain and or sensation. Morphine and codeine are still prescribed controlled substances, whereas heroin is labeled as an illicit drug. Synthetic opiates are not derived from opium, but mimic its effect in the body. For example heroin is very addictive and hard to withdrawal from, therefore the synthetic opiate methadone is used to help patients ween off of heroin with minimal side-affects when compared to the original drug. Another example of a synthetic opiate is oxycodone, this controlled substance is prescribed for chronic pain.



- **Hallucinogens** are drugs that can cause alterations in normal thought processes, perceptions, and moods. An example of a hallucinogen is Marijuana, which is derived from the cannabis plant. The chemical component that makes this plant a hallucinogen is tetrahydrocannabinol (THC). This drug has many potential medicinal

purposes such as a pain reliever and nausea deterrent. Marijuana can also be considered an illicit drug and is widely used around the United States. Other hallucinogens include psilocybin (mushrooms), LSD (lysergic acid), and PCP (phencyclidine).



- **Depressants** are classified as drugs that slow down the central nervous system (CNS). The most popular of the depressants is alcohol. Alcohol is the most widely used and abused drug because of its abundance and variety. The effects of alcohol vary from inhibited judgment and concentration in low doses to extreme irritability or even coma, and possibly death in extreme doses.



- **Barbiturates** are commonly known as “downers” because they relax the user and may cause drowsiness and or sleep. Some examples of medicinal barbiturates are amobarbital, secobarbital, and phenobarbital. An illicit form of barbiturate is methaqualone. Other Barbiturates used medicinally and illicitly are antipsychotics and anti-anxiety drugs, like meprobamate, chlordiazepoxide, and diazepam. Inhalants or Huffing are illicit barbiturates that are sniffed or inhaled to produce a feeling of exhilaration and then quickly falls into drowsiness. Examples are most glues, cleaners, spray paints and aerosol propellants.



- **Stimulants** are a controlled substance that speeds up the central nervous system (CNS). It produce an increased alertness and feelings of well-being, followed by a decrease in fatigue and loss of appetite. These effects are accompanied by restlessness, instability, and oftentimes depression. Amphetamines is the medicinal drug prescribed by health care professionals as Uppers or speed is the street name used for the illicit version of the drug.



- **Cocaine** comes from the coca plant and is a strong stimulant mostly used as an illicit recreational drug. It can be found in a powder form which is snorted inhaled or injected, or found in its cheaper form as crack cocaine and is usually smoked or injected. Its effect on the body may include loss of contact with reality, an intense feeling of happiness, and or agitation.



- **Club Drugs** are synthetic drugs that are often used as a party supplement to stimulate the “rave” experience and be free of any inhibition. One of these synthetic drugs that was once used medicinally is GHB or also known as the illicit drug roofies. The can produce dizziness, sedation, muscle relaxation, and increased libido and often associated with facilitated sexual assaults, rapes, and robberies. Another one of these synthetic drugs is MDMA (also referred as ecstasy and molly) is a mind altering drug that has both stimulant and hallucinogenic effects, like feelings of increased energy, euphoria, emotional warmth and empathy toward others, and distortions in sensory and time perception. Abuse of this illicit drug can cause body system breakdown, severe brain damage, memory loss, and seizures. Yet another synthetic that is abused is Ketamine (also known as Special K). It was originally created as an animal anesthetic, but is now an illicit drug that causes feelings of euphoria, visual hallucinations, impaired motor function, and amnesia.



- **Anabolic steroids** is a controlled substance that is originally used medicinally and is chemically related to the male sex hormone, testosterone that develops secondary male characteristics (androgenic effects) and accelerates muscle growth (anabolic effects). Since it has anabolic effects, it is often used illegally by athletes at all levels to gain a professional edge in competition. Anabolic steroids can either be ingested in pill form or injected. The side effects include liver malfunction, cancer, masculinizing effects in females, diminished sex drive in males, unpredictable moods, personality changes, and depression.



Drug Control Laws

There are varying levels and penalties based on manufacture, distribution, possession, or use of a drug as well as the drug's weight, type, and concentration. According to the Controlled Substances Act, the government maintains five schedules of classifications for controlled substances and are placed in these schedules according to potential for abuse, potential for dependence, and medical value. The U.S. Attorney General has the authority to add, delete, or reschedule a drug as needed. It is important to note that the most severe penalties are associated with Schedule I and II drugs and punishment lessens as the potency strength of the drug lessens.

- **Schedule I** drugs have a high potential for abuse and not currently accepted medical use in the U.S. Examples include heroin, marijuana, methaqualone, and LSD.
- **Schedule II** drugs have a high potential for abuse, currently accepted medical use with severe restrictions, potential for severe physiological and psychological dependence. Examples include opium and its derivatives, cocaine, methadone, PCP, most amphetamine preparations, most barbiturate preparations, and dronabinol (the synthetic equivalent of marijuana, prescribed for medical use).
- **Schedule III** are drugs with a less than high potential for abuse, currently accepted medical use, potential for low to moderate physiological and high psychological dependence. These include all barbiturates not included in Schedule II, such as codeine preparations and anabolic steroids
- **Schedule IV** drugs have a low potential for abuse, current medical use, limited dependence related to Schedule III. Examples of Schedule IV drugs would include Darvon, Valium, Phenobarbital, and Librium; which are all types of tranquilizers.
- **Schedule V** drugs have a low abuse, medical use, less potential for dependence than Schedule IV. These drugs are made up of non-narcotic medicinal ingredients and some opiate drug mixtures. These drugs can be found over the counter.

Conclusion

In Conclusion, drugs and toxins are used and abused for a variety of reasons and it is the role of a forensic toxicologist to detect and identify potential substances that may threaten the health of the individual and or their community. Although forensic toxicologists are limited by the laws that govern their department, they do serve a vital role in efforts to help identify and categorize controlled substances, common drugs, poisons, and show how forensic science is used to fight such crimes.

Videos

Toxicology and Drugs

<https://youtu.be/Uk-ykYYwbu0>

Follow your interest in forensics: Toxicology

<https://www.youtube.com/watch?v=QevbUnyEgzs>

Forensic Toxicology: Utilizing Mass Spectrometry

<https://youtu.be/Vj3OSnQ0BcM>

Forensic Toxicology Controlled Substances Review Questions

1. The current percentage of blood alcohol concentration necessary to consider a person intoxicated is
 1. .10%
 2. .80%
 3. .08%
 4. 8%
2. The role of the forensic toxicologist involves matters that pertain to violations of the law.
 1. True
 2. False
3. A breath test, used to measure alcohol, reflects the alcohol concentrated in the pulmonary vein.
 1. True
 2. False
4. After a screening test has been used to determine the identity of an abused drug, the confirmation test of choice is
 1. Gas chromatography
 2. Gas chromatography/mass spectrometry
 3. Thin layer chromatography
 4. Immunoassay
5. Carbon monoxide is one of the most common poisons encountered in a forensic lab.
 1. True
 2. False
6. Hair can serve as a historical marker for determining drug intake.
 1. True
 2. False
7. A chemical with a pH of 2 would be a
 1. Strong acid

2. Weak acid
 3. Strong base
 4. Weak base
8. Which of the following is NOT true of blood evidence?
1. Blood should be kept refrigerated
 2. When collecting blood, clean the area with a nonalcoholic disinfectant
 3. Utilize a preservative when possible
 4. Collect postmortem blood from one specific site on the body
9. The Breathalyzer requires a very small amount of breath.
1. True
 2. False
10. The test that is based on specific drug-antibody reactions, that is best for detecting low drug levels is called
1. Gas chromatography/mass spectrometry
 2. Gas spectrometry
 3. Immunoassay
 4. Thin layer chromatography
11. Which of the following is best described as an illegal substance?
1. All drugs
 2. Controlled substances
 3. Prescription medications
 4. Illicit drugs
12. The Federal law that establishes the five classifications of drugs is called
1. Controlled Drug Law
 2. Controlled Substance Act
 3. Federal Drug Act
 4. Criminal Penalty Act
13. This type of drug speeds up the central nervous system:
1. Narcotic
 2. Inhalant
 3. Hallucinogen
 4. Stimulant
14. Which of the following color tests turn blue in the presence of cocaine?
1. Marquis
 2. Van Urk

3. Scott
4. Dillie-Koppanyi

15. Alcohol is an example of this type of drug:

1. Depressant
2. Hallucinogen
3. Stimulant
4. Club drug

16. The drug that is administered to heroin addicts to eliminate the addict's desire with minimal side effects is called

1. Oxycodone
2. Opium
3. Methadone
4. Ecstasy

CONCEPT

10

Unit 8 Fingerprint Analysis

TEKS

(9) The student analyzes collected fingerprints or impressions from a simulated crime scene. The student is expected to:

- (A) compare the three major fingerprint patterns of arches, loops, and whorls and their respective subclasses;
- (B) identify minutiae of fingerprints including bifurcations, ending ridges, islands, dots, short ridges, and enclosures;
- (C) distinguish among patent, plastic, and latent impressions;
- (D) perform laboratory procedures for lifting latent prints on porous and nonporous objects using chemicals such as iodine, ninhydrin, silver nitrate, and cyanoacrylate resin;
- (E) perform laboratory procedures for lifting latent prints on nonporous objects using fingerprint powders such as black powder and fluorescent powders;
- (F) explain the Automated Fingerprint Identification System (AFIS) and describe the characteristics examined in the AFIS; and
- (G) compare impression evidence collected at a simulated crime scene with the known impression.

Objectives

In this chapter, topics will be explored such as:

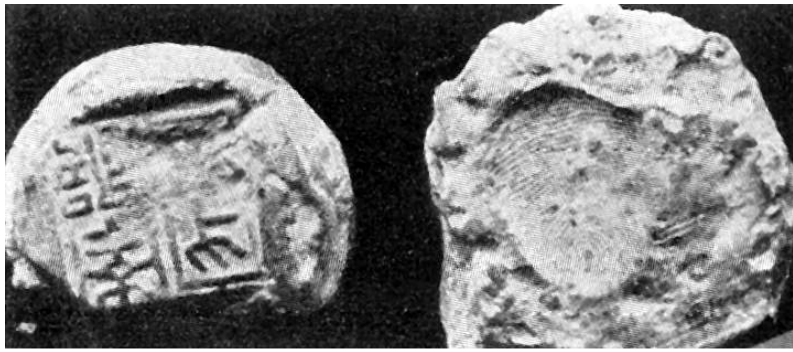
- History
- Fingerprint principles (including patterns and minutiae)
- AFIS (including IAFIS)
- Prints detected at crime scenes
- Discovering and developing prints
- Collection and preservation of prints

History**MEDIA**

Click image to the left or use the URL below.

URL: <http://www.ck12.org/flx/render/embeddedobject/170890>

Identification of individuals by the use of fingerprints has been around for many years, and not only in the United States. Evidence has been found that proves that fingerprints were used thousands of years ago (as early as 221 B.C.) in places such as China, Japan, and India. In some instances, it is unknown exactly as to why these prints were used during these times. In others, it is apparent that prints were used as a form of signature and to show the authenticity of an author's work.



http://fingerprintingssc.weebly.com/uploads/1/4/1/8/14188561/5580509_orig.jpg?234

17th and 18th Century

In the 17th century, scientists such as Dr. Nehemiah Grew, anatomists such as Govard Bidloo, and physiologists such as Marcello Malpighi made friction skin ridge observations, published details of skin and papillary ridges, and determined that these ridges helped to increase friction to grasp items. Yet, the discovery that these ridges were unique was not introduced until the 18th century by the German doctor J.C.A. Mayer.

19th Century

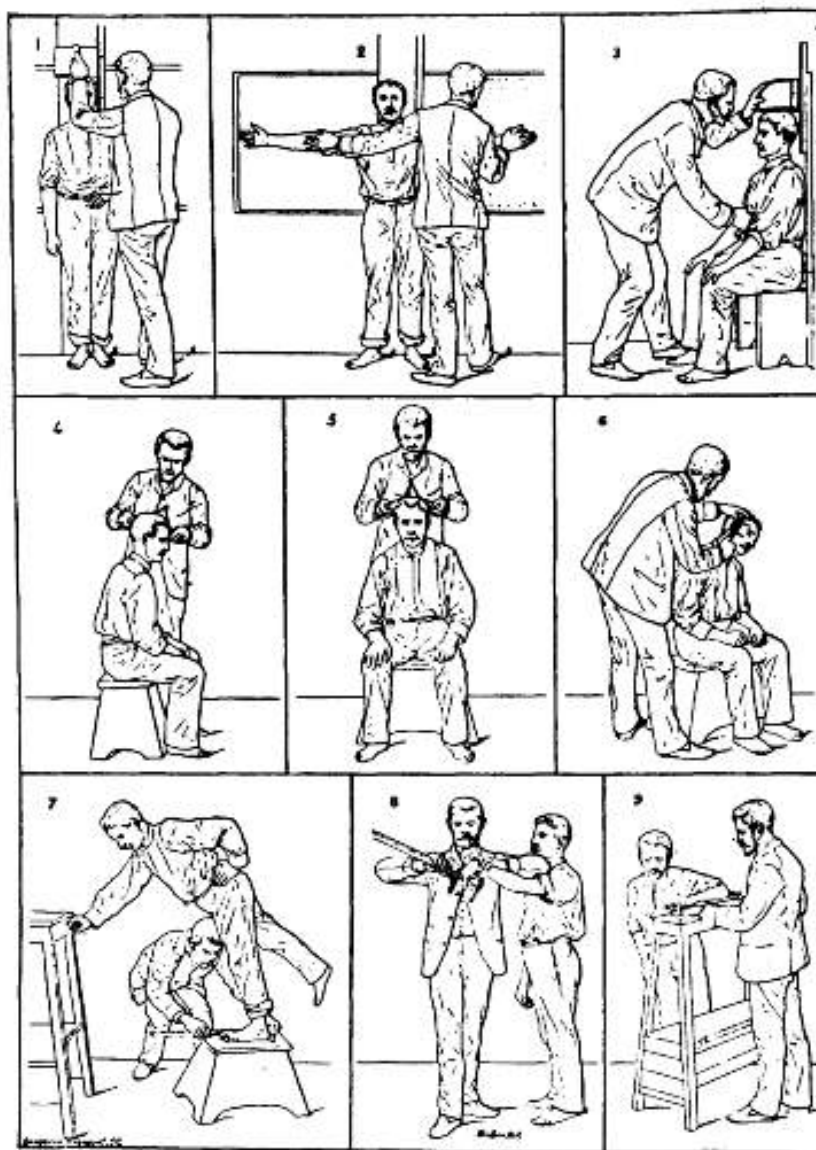
In the 19th century, a German professor Dr. Johannes Purkinje, classified prints into nine categories and allocated a name to each. Sir William James Herschel had Indians sign by stamping their handprint on documents, which were then perceived to be valid documents. He also observed that fingerprints do not change over time, and noted that these prints could be used in preventing fraud. Henry Faulds noticed the importance of friction ridges in respect to their uniqueness, how they could be classified, and their intransience. He published a journal specifying their uniqueness and how they could be used as evidence to either convict or exonerate an individual.



Henry Faulds

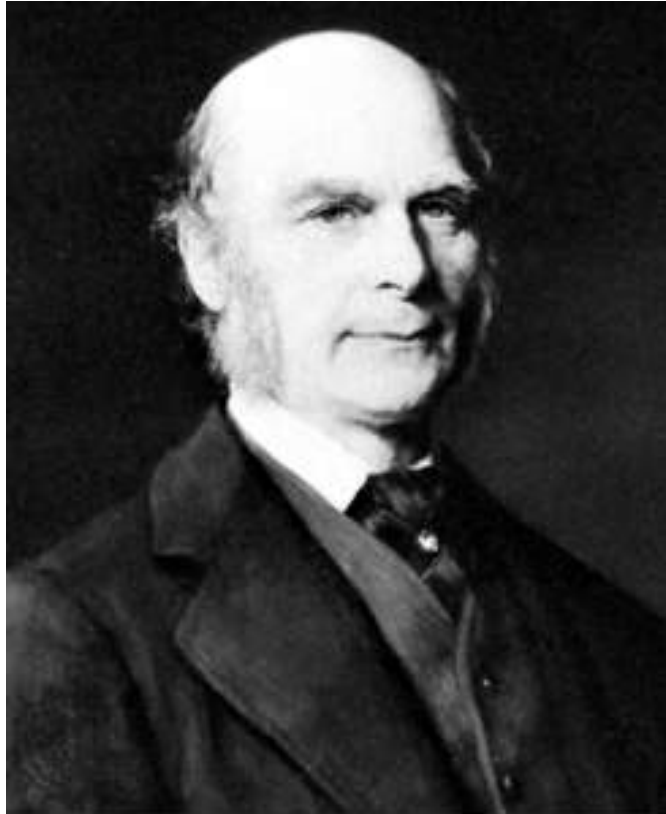
Fingerprint ridges were gaining momentum, but were yet to be widely accepted as a means of identification. In 1879, Alphonse Bertillon implemented a system of identification called anthropometry. This involved taking people's body measurements such as their height, reach (middle finger to middle finger of outstretched arms), trunk, length of head, width of head, length of right ear, width of right ear, length of left foot, length of left middle finger, length of left little finger, and length of left forearm. This method was the first method of personal identification that was used from 1882 until 1914. It would eventually lose credibility with the continuing study and acceptance of fingerprints.

RELEVÉ DU SIGNALEMENT ANTHROPOMÉTRIQUE



1. Taille. — 2. Envergure. — 3. Buste. --
4. Longueur de la tête. — 5. Largeur de la tête. — 6. Oreille droite. —
7. Pied gauche. — 8. Mèdus gauche. — 9. Coudée gauche.

In the 1880's Francis Galton further studied anthropometry and fingerprinting. He added the printing of all ten fingers to the anthropometric measurements. He is known for writing the first book called *Finger Prints*. In the book, he stated that friction ridge skin was unique and permanent. He assigned prints to three basic patterns, and gave suggestions on how to classify prints. He is also known for identifying and naming minutiae, which were then known as Galton details. In 1891 Juan Vucetich, from Argentina, studied Galton's work. He recorded criminals' fingerprints and developed his own classification system, which was the first noted use of fingerprints by law enforcement.



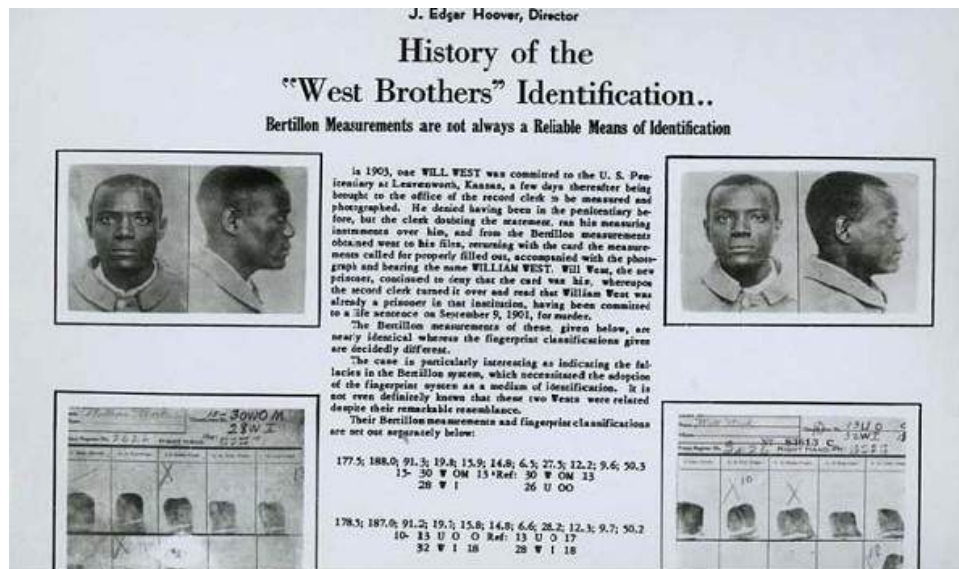
Francis Galton

In 1894, Sir Edward Richard Henry joined forces with Galton and Indian police officers to develop a system to classify fingerprints. In 1897, India adopted fingerprinting to be used instead of anthropometry for prisoner identification. At the turn of the century, England advocated that all criminal records be classified by the fingerprint system as well. The Henry Classification System and fingerprints would ultimately be put into practice in most English-speaking countries.

20th Century

In 1902, Dr. Henry P. de Forest fingerprinted civil service applicants in New York to avert imposters from attempting to pass a test for another individual. Applicants were fingerprinted at various occasions such as when they handed in an application, when they turned in a test, and when they reported for duty. In 1903, New York Captain James H. Parke implemented the American Classification System, which was the first use of fingerprinting for criminal records in the United States.

History does tell a story in which two individuals, deemed to be twins (although, never proven to be true nor that they were actually related), were mistaken for the same person with the use of anthropometry. Will West was arrested in 1903 and taken to Leavenworth. He stated that he had no priors. Anthropometric measurements were taken along with a photo. The prison ran a prison records check and identified a man by the name of William West, with almost exact measurements and facial resemblance. Confusion arose because the records stated that he was currently imprisoned at the facility. They believed that somehow, William had escaped. Prison guards checked his cell, in belief that he would not be there, but to their avail, he was in his cell. The prison records were placed side-by-side and the results were almost exact in regards to the anthropometric measurements and photos, but upon examining their fingerprints, there was clear distinction between the two men. Anthropometry was thus proven to be ineffective as a means of personal identification. Many people may share the same measurements, but will never possess the same fingerprints, not even identical twins.



<http://collectivelifestyle.com/wp-content/uploads/2014/04/aaa2-600x350.jpg>

Inspector John Kenneth Ferrier from New Scotland Yard was an important figure at the 1904 World's Fair in Saint Louis. Inspector Ferrier conversed with many people in charge of their police departments in United States about fingerprints and how anthropometry had failed in identifying The West individuals, but fingerprints were able to differentiate between the two. After the fair, he stayed in the United States to educate about fingerprinting and how to develop latent prints, and those taught the material went on to teach law enforcement and military all over the United States.

Still in 1904, Inspector Ferrier and Major M. W. McClaughry fingerprinted all inmates imprisoned at the Leavenworth federal prison, which was the first U.S. compilation of fingerprints. Over the years, prisons amassed large collections of fingerprints. In 1924, Leavenworth files and the National Police Bureau of Criminal Identification files were merged to form the Identification Division in the U.S. Justice Department's Bureau of Investigation, which later became what we now know as the FBI.



Fingerprint Principles

Galton was a major pioneer in the advent of fingerprinting becoming accepted as a means of identification and individualization. Since then, many individuals have studied and expanded on the work of fingerprinting. Certain principles have been developed and perfected that help individuals understand the uniqueness, stability, and classification of prints.

First Principle: A Fingerprint Is an Individual Characteristic; No Two Fingers Have Yet Been Found to Possess Identical Ridge Characteristics

The probability that two prints in the entire world could be similar is nearly nonexistent. It is supported by Galton's theoretical calculations. It is also proven due to the fact that fingerprinting as a source of identification has been in existence for over a century and no two prints have yet to be found that are exactly the same. The FBI has the largest database in the world, and even then, all prints in the database are unique.

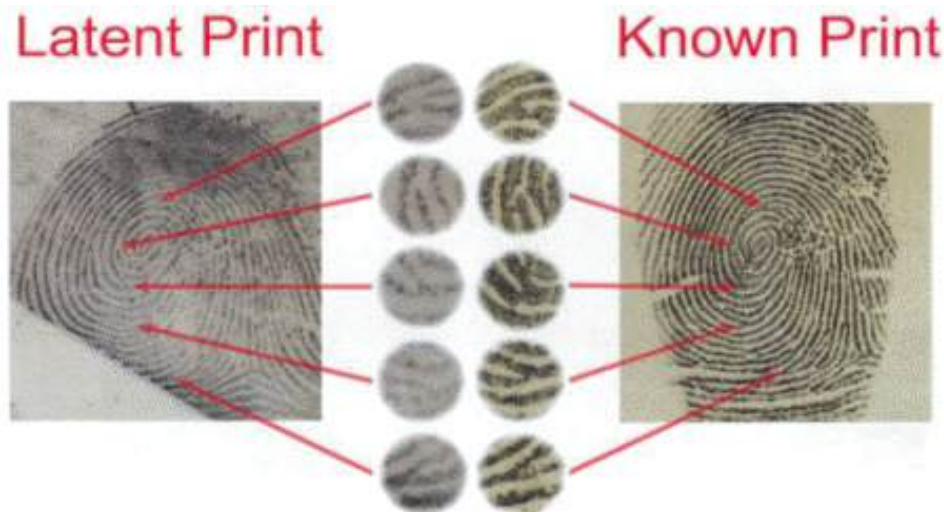


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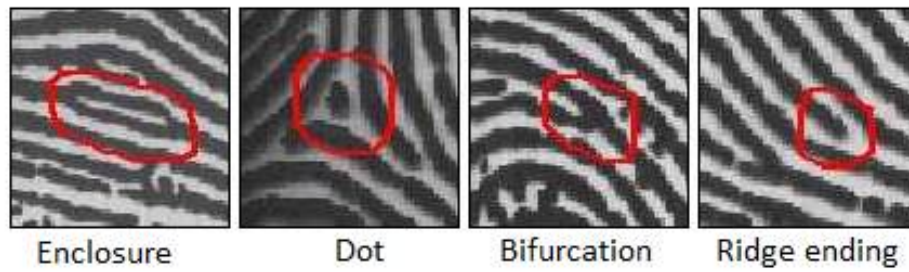
Many people may have the same general pattern, but the difference in the prints comes down to the uniqueness, location, and quantity of the **ridge characteristics**. Ridge characteristics and **minutiae** are used interchangeably and are the unique characteristics that are used to make a correlation between two fingerprints. If there is a positive match between two prints, the type of minutiae must be the same and must be in the same exact location. A side-by-side assessment must be done in order to establish commonality between the two.



<http://dupageforensics.org/images/fingerprint%20comparison.gif>

Some of the most common minutiae seen are the enclosure, dot, bifurcation and ridge ending. The **enclosure** is a ridge that breaks into two ridges and eventually connects to form one ridge again. The **dot** is a ridge all on its own and is the same diameter as its length, which makes it nearly a perfect circle. A **bifurcation** is formed when one

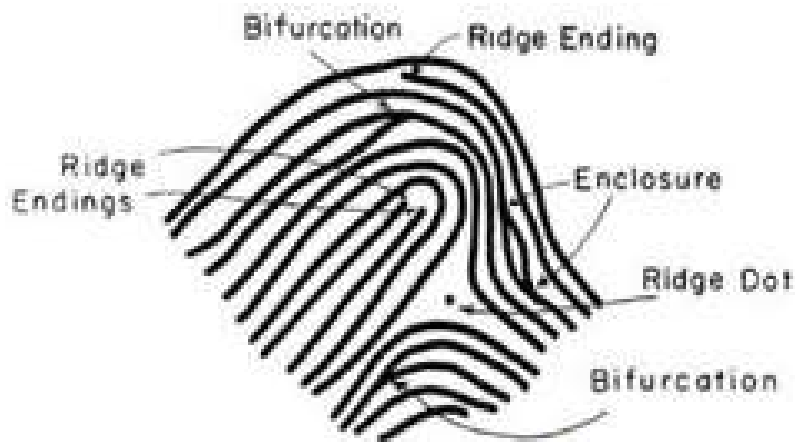
ridge separates and forms two ridges. A **ridge ending** is a solitary ridge that stops in its travels and does not connect to anything else. Many other ridge characteristics exist and are featured below.



Minutiae	Example	Minutiae	Example
ridge ending		bridge	
bifurcation		double bifurcation	
dot		trifurcation	
island (short ridge)		opposed bifurcations	
lake (enclosure)		ridge crossing	
hook (spur)		opposed bifurcation/ridge ending	

http://www.novaindustries.com.au/wp-content/uploads/2014/04/20101103_65.jpg

A single fingerprint may easily contain over one hundred minutiae. It is easy to identify ridge characteristics if the print is found in its entirety. Most crime scene prints that are found only show a segment of the complete print, and may make it difficult to find a substantial number of ridge characteristics. For that matter, as few as 8-16 minutiae have been accepted to make a positive correlation between two fingerprints. An expert must make the final verdict on whether two prints are one and the same.

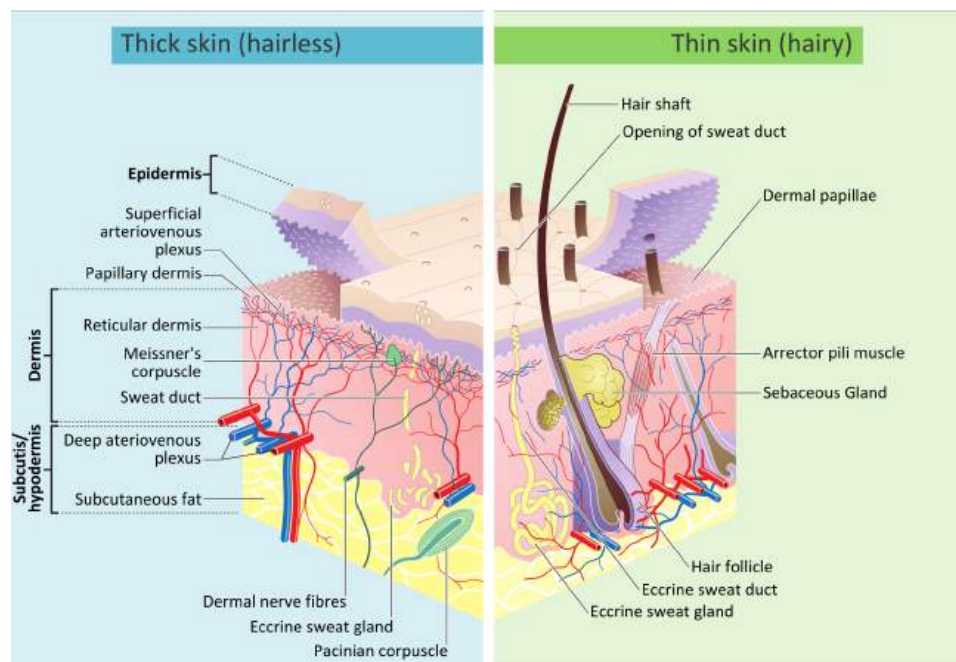


http://o.quizlet.com/i/qYSYNQ0QdH4uHuZ0WxBixA_m.jpg

Second Principle: A Fingerprint Remains Unchanged During an Individual's Lifetime

Fingerprints form before birth. They fully form during gestation in the mother's womb. They are found on the entire finger, thumb, palms of the hands, and the total surface of the bottom of the foot. Prints may grow larger throughout life, but other than size, the pattern and minutiae stay the same. Prints not only help to decipher one person from another, they also help with gripping and holding objects.

The morphology of an inked fingerprint consists of hills, which appear black and valleys, which appear white. The surface is also embedded with sweat pores. These ridges help to grasp surfaces and resist slippage, and the sweat pores allow for the release of sweat and oils. When a person touches any surface, these oils and sweat are passed on, which transfers the fingerprint pattern onto the surface or object. These transfers are not readily seen, and are known as **latent prints**. There are ways to develop or reveal a print, which will be discussed later.



The skin is the largest organ in the body and is made of three layers called the epidermis, dermis, and hypodermis. The **epidermis** is the protective layer of the skin and constantly undergoes cell division to replace lost or damaged cells in the skin. The **dermis** controls temperature, is responsible for skin's flexibility, and provides the epidermis with nutrients through the blood vessels that are embedded within the layer. Structures found within the dermis also include lymph vessels, hair follicles, apocrine, eccrine, and sebaceous glands, nerve endings, and collagen and elastin. The **dermal papilla** is found on the upper layer of the dermis and give rise to the form and pattern of the ridges on the epidermal skin. The **hypodermis** is made of fat and collagen cells. It is responsible for insulating the body, conserving the body's heat, protecting the organs, and serves as an energy reserve for the body.

Many criminals in the past attempted to obliterate their fingerprints, but had no success. John Dillinger was a famous bank robber and murderer during the Great Depression. He decided to take acid to his fingerprints in attempt to burn them off completely. When his body was taken into the morgue after being killed, his prints were taken and were still visible. Regardless of what is done to one's prints, they do go through the healing process and will eventually grow back.



MEDIA

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URL: <http://www.ck12.org/flx/render/embeddedobject/170894>

Attempting to do away with fingerprints really does not make any sense. The tips of the fingers are not the only part that contains ridges. The entire palm side of the hand is covered completely with ridges. If the tips are gone, a person's hand will still make contact with the object or surface that it touches, and will leave unique prints that will be unique to that individual. Also, if the skin is damaged, a scar will be left behind which will be somewhat like a ridge characteristic as well. No two people will have the same exact type of scar, size, or location, and will just be another identifying characteristic for that individual. At the end of the day, it is simply impossible to alter one's fingerprints, unless there is total mutilation.



Scar



Detail from scar

http://www.odec.ca/projects/2004/fren4j0/public_html/unusual_fingerprints_files/image005.GIF

Third Principle: Fingerprints Have General Ridge Patterns That Permit Them to Be Systematically Classified

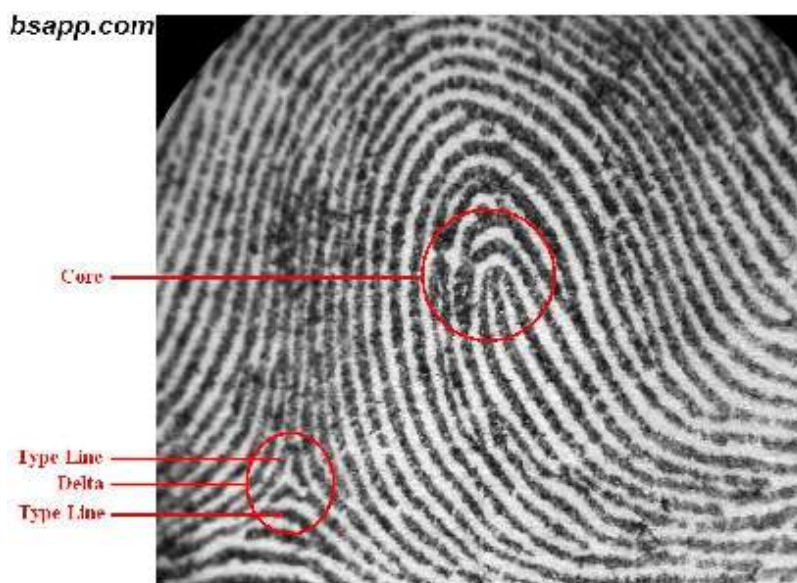


MEDIA

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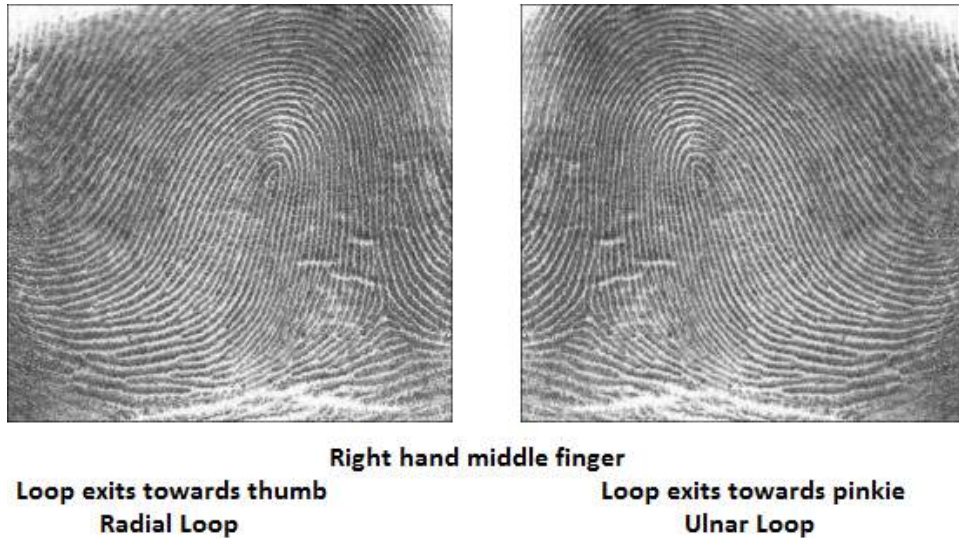
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Fingerprint ridge patterns are divided into three major groups, which are loops, whorls and arches. 60% of the human population has loops. Approximately 35% has whorls, and the remainder 5% has arches. When deciphering whether a fingerprint is a loop, whorl, or arch, one key characteristic to look for is a delta. A **delta** is a pattern that bears a resemblance to the Greek letter delta. It's the point on a friction ridge at or nearest to the point of divergence of two type lines. **Type lines** are the two innermost ridges that begin parallel, then diverge and surround the pattern.



http://bsapp.com/forensics_illustrated/forensic_text_adobe/text_unit_4_fingerprints.pdf

Loops



The first item to look for when determining the pattern is the delta. If there is one delta, the pattern is a loop. Another characteristic of a loop is that a ridge will enter on one side, curve around, and exit on the same side from which it entered. There are two types of loops depending on which side the loop exits. If a loop exits towards the pinkie (points towards the ulna bone), it is called an **ulnar loop**. If it exits towards the thumb (points towards the radius bone), it is a **radial loop**.

Whorls



Whorls will possess two or more deltas. A **plain whorl** has two deltas that are nearly parallel to one another and has a large circular pattern. If a line is drawn between the two deltas, and any part of the circular pattern passes that line, it definitely is a plain whorl. On the other hand, a **central pocket whorl** has two deltas that are not parallel to one another. A line is drawn between these two deltas, and the circular pattern will not cross the line. A central pocket whorl is quite smaller than the plain whorl. It also appears to resemble a lollipop, a candy mounted on a stick. A **double loop whorl** also contains two deltas. The difference lies in the fact that there is no circle present. Instead, it has two loops that seem to make the letter “S” shape. **Accidental whorls** may have two or more deltas and also have two different patterns. It may be a combination of a loop and a plain whorl, or may contain a loop and tented arch. It also may not resemble any of the other patterns.

Arches



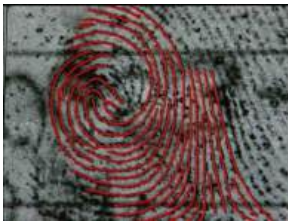
Plain Arch



Tented Arch

Arches are devoid of any deltas and appear as hills. The **plain arch** is simple. The ridges enter on one side and exit the opposite side. The **tented arch** is similar to the plain arch, but differs in that it has a spike in the middle, causing it to look somewhat like a tent.

AFIS



MEDIA

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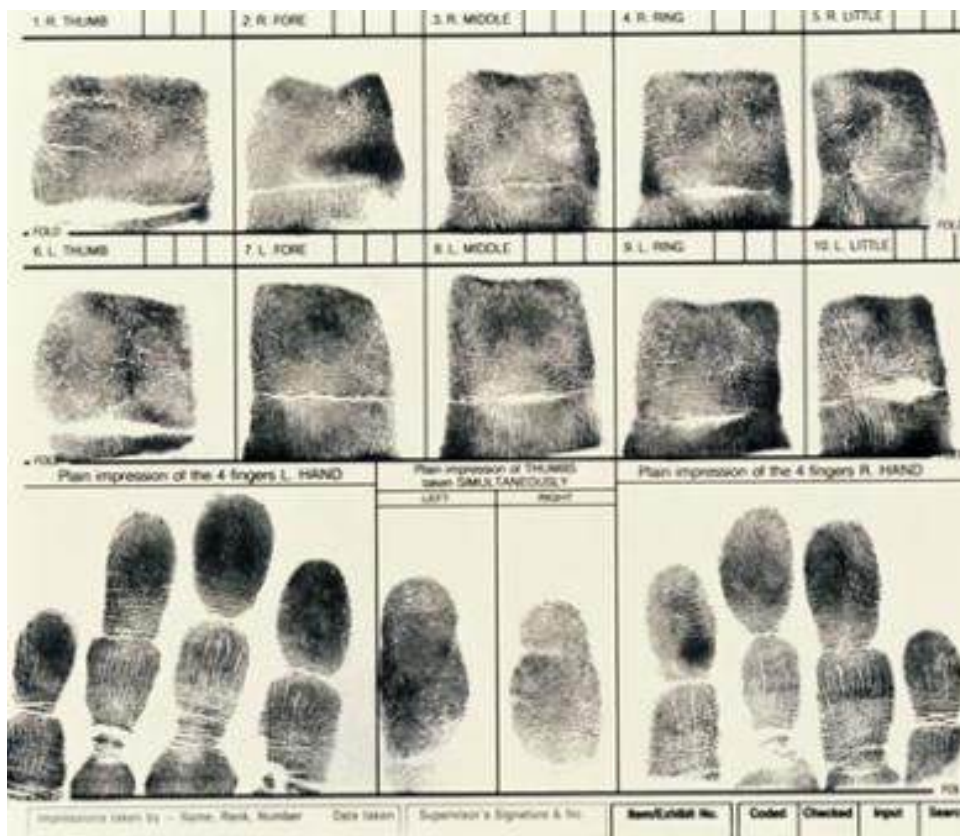


MEDIA

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Fingerprint records were kept as manual files (ten rolled fingerprints per card) that had to be cross-referenced against an unknown crime scene print through the labor intensive work of technicians. The collection of fingerprints grew to the hundreds of thousands from the 1900's and quickly neared and passed the million mark by 1960. It was evident that manually performing this task would become an arduous duty to complete. It would require too many individuals and too much time to attempt to match one print against the millions of files in existence. There had to be a better system that would reduce the amount of time to search the files.



<https://www.nfstc.org/wp-content/uploads/2011/04/Tenprint-Training3.jpg>

In the 1960's, research began to somehow progress these prints into an electronic database that would cut the manual labor downfalls. In 1963, Special Agent Carl Voelker of the FBI's Identification Division found assistance with this problem with the National Institute of Standards and Technology. Their task was to somehow automate the manual system of identifying minutiae in the same location in two prints. Many other agencies and countries delved into development of this new system. With many hours of research and effort, the Automated Fingerprint Identification System was born.



<http://www.co.berks.pa.us/Dept/DA/PublishingImages/dsc05112a.jpg>

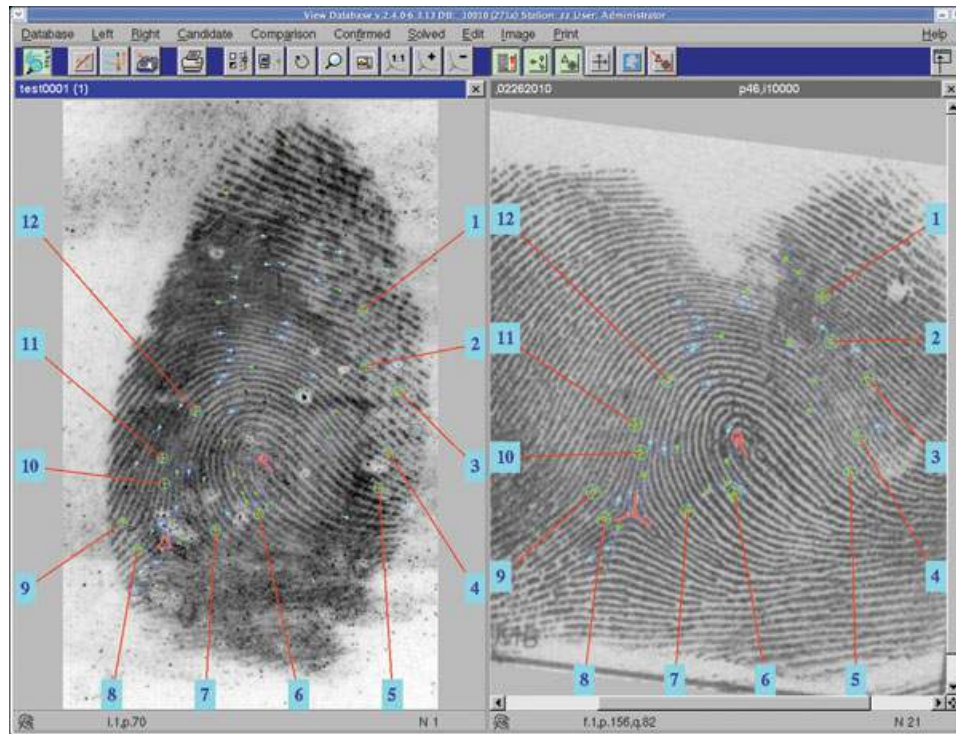
AFIS is used mostly by law enforcement to identify criminals suspected of committing a crime or linking a culprit to an unsolved crime. It may also assist in identifying unknown bodies due to homicide or natural disasters. Law Enforcement may utilize AFIS by looking for a new tenprint record against the records of the current tenprint database or the current unsolved database of unsolved crimes, or by looking for a latent print from a crime scene against the current tenprint database or current unsolved crimes database.

The **tenprint subsystem** is responsible for using fingerprints obtained while a person is under arrest to establish if he or she has an existing record, has a warrant, or are claiming to be someone that is not truly them. Inked prints are a thing of the past. Fingers and palms are rolled on the **livescan** and the scanner underneath reads and processes the information. That information is checked by a technician and is then sent to AFIS. Here, the fingerprints are searched against the database of current records. An automated tenprint inquiry will usually search for ridge characteristics from one finger. In usually under a minute, AFIS will explore millions of prints and return hits on the closest matches to the print searched. Fingerprints obtained through arrest are usually clear and should not be difficult to match if a person has been arrested beforehand. The technician will compare the arrested person's prints to the prints deemed as possible matches by AFIS to verify if there is a correlation, and thus a match.



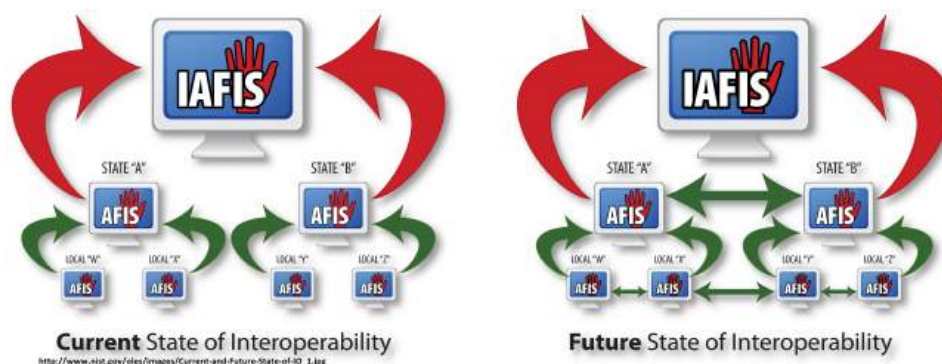
<http://i.ytimg.com/vi/9mBuYH2g35A/hqdefault.jpg>

The **latent print or criminal identification** subsystem uses latent prints taken from crime scenes or from any evidence submitted. Latent prints are not found in perfect condition as those taken while a person is being booked into jail. They may be partial and not readily visible once developed by powder or any other method deemed appropriate, and may require that it be digitally enhanced. A latent print examiner will then scan a latent print developed and lifted from a surface and plot the ridge characteristics. The latent print is searched against the AFIS database to determine the closest matches. The examiner will then have to compare the latent print to the possible matches deemed by AFIS to make the final decision as to whom the latent belongs to. It may take minutes to hours before there is an answer as to who the print may belong to.



<http://www.spexforensics.com/images/cms/content/printquest-101-l.jpg>

AFIS does not exist without problems. Cities, counties and states could choose between different vendors in competition with one another for an AFIS program. This created a problem, due to the fact that they were very different software systems that could not communicate with one another. Local AFIS jurisdictions are able to correspond with state AFIS programs, and the state may correspond with federal IAFIS. One local AFIS jurisdiction is not able to communicate with any other local jurisdictions, nor may states communicate with other states due to these different programs in existence. In the future, it is anticipated that all local jurisdictions and states may communicate with one another.



IAFIS

The Integrated Automatic Fingerprint Identification System is operated at the federal level through the FBI. The greatest attribute of IAFIS is that it does not only deal with fingerprints, but also contains information such as criminal histories, photos, scar and tattoo information, physical characteristics, and aliases. It also contains fingerprints for those individuals that work for the government such as the military personnel as well as prints from known and supposed terrorists. IAFIS contains more than 70 million people in its files and approximately 34 million civil

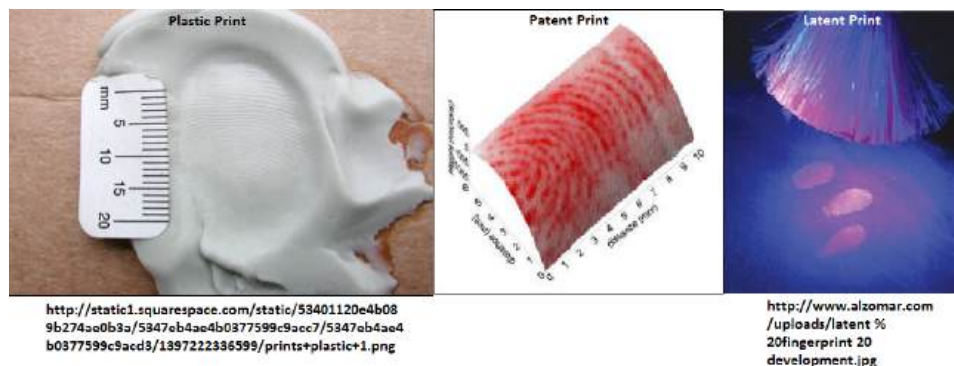
prints. Furthermore, IAFIS has speedy response times in regards to obtaining a match. It may find a match in as little as an hour or two to twenty-four hours.

Prints Detected at Crime Scenes

There are three types of prints that are commonly found at crime scenes. **Patent prints** are visible prints. Fingers may come in contact with a colored substance such as dirt or blood, which in turn will be deposited onto the entity that is touched. These prints will be photographed with a high resolution camera.

Latent prints are the exact opposite. They are undetectable by the human eye, but are still technically present. When a person touches something, the oils and sweat that emerges from the sweat pores are passed onto the surface that is touched. It may be initially invisible, but may be developed with powders or chemicals to render it visible. When the powder is applied, a photograph will be taken. It is then covered with fingerprint tape, then lifted and placed on a labeled card for preservation.

Plastic prints are 3D depressions caused by driving the finger into a soft or wet material such as wax, or paint, or tar. The resulting impression is easily detectable. A high resolution photograph will be taken to preserve the print.



Discovering and Developing Prints



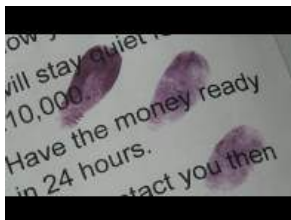
MEDIA

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Investigators are frequently using alternative light sources to take a closer look at surfaces that commonly have latent fingerprints on them such as door knobs, telephones, etc. These light sources may be LED, laser, fluorescent or UV light. It is also important that the light source may be adjustable so that the print will be the only item glowing, and not the surface that it is on. Once a print is identified with the light source, a photograph will be taken before it is developed by powders or chemicals.



MEDIA

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The surface plays an important role in deciding which development method will be used to reveal the latent print. The surface may either be porous or non-porous (smooth or rough). The definition of **porous** is having minute spaces or holes through which liquid may pass. Porous materials therefore would be items such as paper, cardboard, and wood. In order to develop prints on these surfaces, a chemical treatment must be used.

Porous Wood



http://workshopcompanion.com/How/Design/Nature_of_Wood/1_Wood_Grain/1_Wood_Grain_Images/NOW_1_5.jpg



MEDIA

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URL: <http://www.ck12.org/flx/render/embeddedobject/170906>

Ninhydrin is commonly used on porous surfaces. The chemical is attracted to the amino acids in sweat and reveals the print in a blue to purple coloration. Prints that have a high amount of sweat will usually develop within a couple of hours, whereas weak prints may take up to two days to mature. If heat is added to the process, the print may appear in a matter of minutes. A benefit of using this method is that the print does not need to be fresh in order for the color to cultivate. It has been found that prints as old as fifteen years were still capable of development.



MEDIA

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URL: <http://www.ck12.org/flx/render/embeddedobject/170908>

Iodine is special in that it will go through a process called **sublimation**. In this process, the iodine crystals do not go into a liquid phase, then a gaseous phase. The crystals skip the liquid phase altogether and turn into gas. When crystals and the porous specimen to be processed are placed into a chamber and heat is applied, the iodine fumes will hold fast onto the oils from the print, turning it into a yellow to brown color. A photograph will need to be taken promptly, as the color will not stay permanently. A starch solution may be sprayed onto the print rendering it a blue to black color. It still will not make the print permanent, but the print will last anywhere from weeks to months through the addition of the starch solution.



http://www.bvda.com/images/b745_use.jpg



MEDIA

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URL: <http://www.ck12.org/flx/render/embeddedobject/170910>

Another method to use on porous articles is treatment with silver nitrate. It binds to the salt found in a sweaty fingerprint. Silver nitrate is mixed with water and is sprayed onto the print. It is then placed in direct sunlight and allowed to air dry. Once dry, the porous material is rinsed with water and allowed to dry again. The print will be visible in a dark gray to black tint. Silver nitrate has been known to develop old prints, and when ninhydrin and or iodine fuming fail, silver nitrate may prove to be valuable. Silver nitrate is known to be quite destructive, so it is best to use it as a last resort so it does not affect the surface and or handwriting found on the piece of evidence.



<http://www.forensicmag.com/sites/forensicmag.com/files/styles/large/public/print072613.jpg>



MEDIA

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URL: <http://www.ck12.org/flx/render/embeddedobject/170912>

Non-porous surfaces are those surfaces impermeable to water. In a sense, they are solid surfaces. Smooth surfaces consist of painted surfaces, plastic, and glass. Rough surfaces may include anything with texture such as vinyl and leather. Crime scene investigators will use powder on a brush to develop a print then lift the print with tape. Powder is also used for rough surfaces, but the print is lifted with a gel-lifter or a silicone casting material. These materials will ensure to grab anything within the grooves that regular tape would miss. The type of powder used depends on

the surface the print will be developed from. Cyanoacrylate fuming may also be used to ensure that the print will not be destroyed through brushing techniques.

Nonporous Glass



http://www.menards.com/main/store/20090519001/items/media/Millwork/Shape/ProductLarge/clear_float_glass.jpg



MEDIA

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URL: <http://www.ck12.org/flx/render/embeddedobject/170913>

Camel hair and fiberglass brushes, along with magnetic wands are ordinarily used with powders to develop latent prints on non-porous surfaces. The powder will hold fast onto the secretions released from the sweat pores. **Black powder** is the most common type used and is made of either carbon or charcoal with an added binder. It will contrast greatly against a white surface or a light-colored surface. Once it is placed on a labeled card, the ridges will appear black against the white card background.



MEDIA

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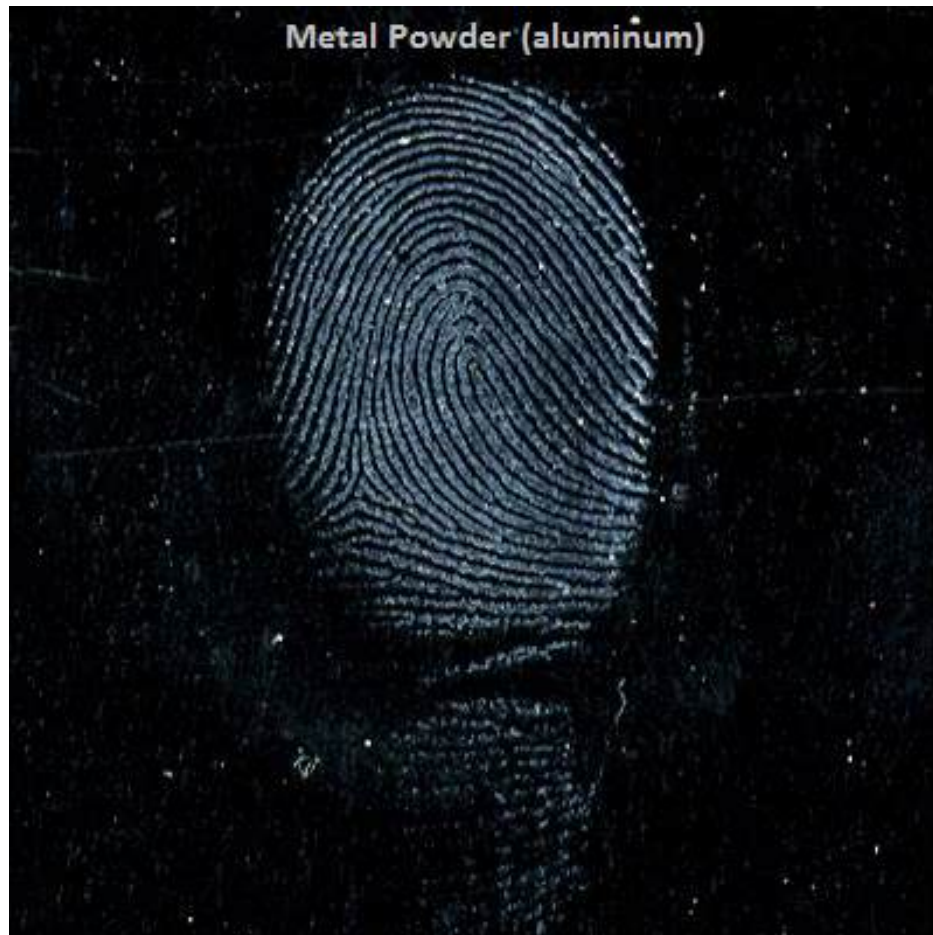
URL: <http://www.ck12.org/flx/render/embeddedobject/170916>

Magnetic powder requires a specific magnetic wand in order to attach to and apply the powder. It is used on various surfaces such as plastic, rubber, foam, leather, and shiny surfaces. This is a great method to use due to the lack of bristles on a brush that may rasp against a print and destroy it. One negative aspect of the magnetic wand is that it cannot be used upside down.



<https://s-media-cache-ak0.pinimg.com/736x/8b/14/36/8b1436f490fef7aafde8bd6ab1e1a118.jpg>

Various metals can be used to make **metal powders**. Aluminum, stainless steel, iron, cobalt, and nickel are a few that these powders may be generated from. Metal powder can be used on dark surfaces, mirrors, glass, and even metal surfaces. When a photograph is taken of a metal print on a metal surface, the metal surface will photograph black which will provide a contrast against the print.



http://d1zh4ok0q8k7dm.cloudfront.net/media/catalog/product/cache/1/image/9df78eab33525d08d6e5fb8d27136e95/d/p/dp_white_result.jpg



MEDIA

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URL: <http://www.ck12.org/flx/render/embeddedobject/170902>

Fluorescent powders have become increasingly popular. They may be used on many surfaces and rely on a fluorescent light to help the print fluoresce and distinguish itself against the background from which it is on. It is important to not have an abundant amount of powder on the brush, as it will consume the print and make it hard to visualize the ridges.



MEDIA

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URL: <http://www.ck12.org/flx/render/embeddedobject/170918>

Cyanoacrylate fuming has also become an increasingly popular practice. This technique may actually be used on porous and non-porous surfaces, but has been extremely accepted with non-porous materials. It works great on nearly every surface such as metal, glass, rough surfaces, paper and plastic. The evidence being treated is placed into a chamber. Underneath the evidence, super glue will be heated and will vaporize. The fumes will attach onto the sweat, producing a white print. From this point, the powder desired is applied. It will lastly be lifted by applying tape, lifting the tape, and placing the recovered print on a labeled card.



Collection and Preservation



MEDIA

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- All prints must be photographed with and without scales.
- Small items may be packaged in paper bags or envelopes and sent to the lab.
- Papers with possible prints should be placed separately in an envelope.
- The paper may also be placed in between two pieces of cardboard, wrapped in cellophane, and sent to the lab if manila or cellophane envelopes are not available.
- Large items such as glass and guns should be secured with string onto a surface to prevent moving and coming into contact with other surfaces and/or objects.
- If the item is not transportable, the print must be lifted.
- Lifting is done by locating a print, applying powder, smoothing tape over ensuring that bubbles are not present, lifting the tape in one solid motion, and applying the tape onto a labeled card that contrasts with the color of the powder.

Chapter Summary

- The use of fingerprints has been in existence as early as 221 B.C. in Japan, China, and India.
- Many discoveries were made from the 17th century throughout the 20th century.
- No two people in the entire universe will have the same exact fingerprints.
- This is not due to the three basic patterns, but due to the uniqueness, location, and quantity of the ridge characteristics (minutiae).

- Fingerprints form during gestation and will not change during a person's lifetime, other than growing larger throughout life.
- Regardless of what is done to obliterate one's prints, they do go through the healing process and will eventually grow back.
- Fingerprint ridge patterns are divided into three major groups, which are loops, whorls and arches.
- AFIS is used mostly by law enforcement to identify criminals suspected of committing a crime or linking a culprit to an unsolved crime.
- An unknown is searched in the database until AFIS returns hits on the closest matches to the print searched.
- The technician will compare the arrested person's prints to the prints deemed as possible matches by AFIS to verify if there is a correlation, and thus a match.
- There are two AFIS subsystems. They are the tenprint subsystem and the latent print or criminal identification subsystem.
- The tenprint subsystem is responsible for using fingerprints obtained while a person is under arrest to establish if he or she has an existing record, has a warrant, or are claiming to be someone that is not truly them.
- The latent print or criminal identification subsystem uses latent prints taken from crime scenes or from any evidence submitted.
- IAFIS does not only deal with fingerprints, but also contains information such as criminal histories, photos, scar and tattoo information, physical characteristics, and aliases.
- It also contains fingerprints for those individuals that work for the government such as the military personnel as well as prints from known and supposed terrorists.
- There are three types of prints that are commonly found at crime scenes. They are patent (visible by coloration), latent (invisible), and plastic (visible by a resulting impression).
- Investigators are frequently using alternative light sources to take a closer look at surfaces that commonly have latent fingerprints on them such as door knobs, telephones, etc.
- The surface plays an important role in deciding which development method will be used to reveal the latent print. The surface may either be porous or non-porous (smooth or rough).
- Ninhydrin is commonly used on porous surfaces and is attracted to the amino acids in sweat and reveals the print in a blue to purple coloration.
- Iodine fumes will hold fast onto the oils from a print on a porous surface, turning it into a yellow to brown color.
- Silver nitrate binds to the salt found in a sweaty fingerprint on a porous surface, turning it dark gray to black.
- Black powder is the most common type used on non-porous surfaces and is made of either carbon or charcoal. It will contrast greatly against a white surface or a light-colored surface.
- Magnetic powder is used on various non-porous surfaces such as plastic, rubber, foam, leather, and shiny surfaces.
- Metal powder can be used on non-porous dark surfaces, mirrors, glass, and even metal surfaces.
- Fluorescent powders may be used on many surfaces and rely on a fluorescent light to help the print fluoresce and distinguish itself against the background from which it is on.
- Cyanoacrylate fuming works great on nearly every surface such as metal, glass, rough surfaces, paper and plastic.
- Collecting and packaging evidence is of utmost importance when dealing with fingerprint evidence.

Review Questions

Short Answer

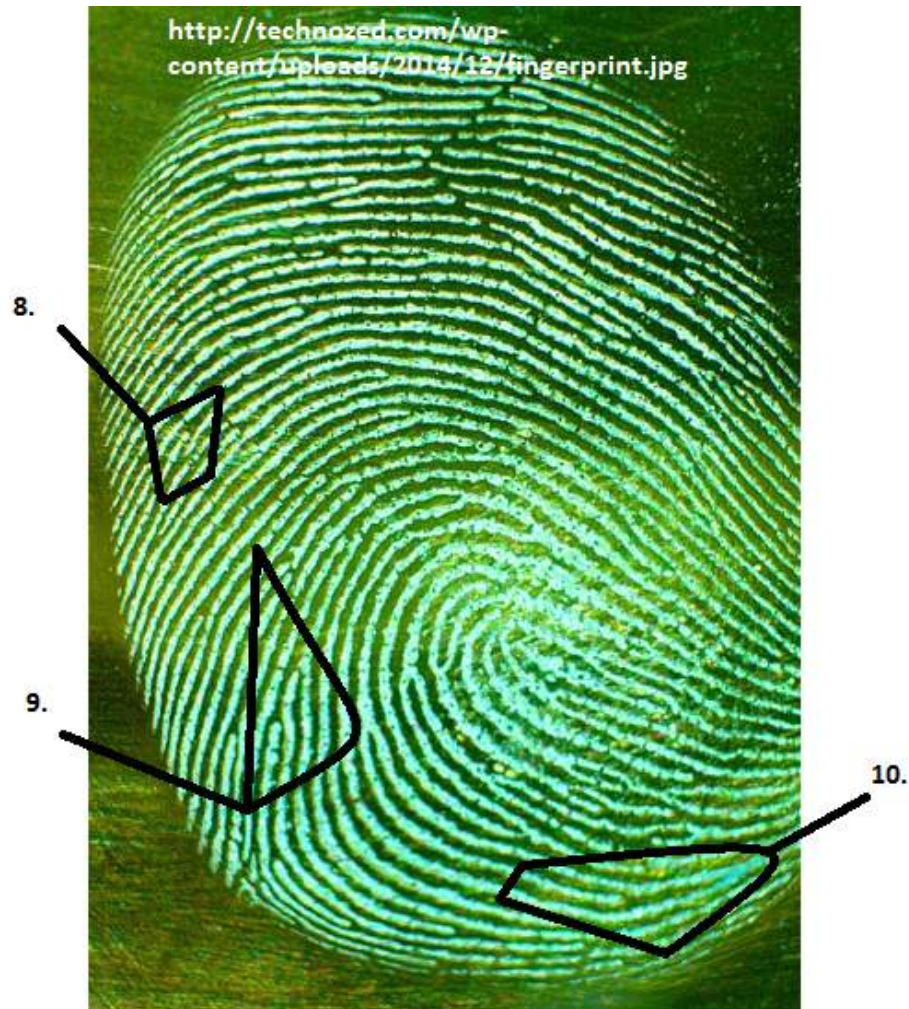


1. This print is taken from the left pinky. Identify the distinct pattern.

While searching a murder scene, you discover the following items that may contain latent fingerprints. Indicate whether prints on each item should be developed using fingerprint powder or chemicals (black powder, gray powder, magnetic powder, ninhydrin, superglue). Each choice can only be used once.

2. Leather sofa-
3. A mirror-
4. Newspaper-
5. Electrical tape-
6. White painted wall-
7. Describe the three basic steps used to lift a nonporous fingerprint.

Identify the following minutiae within the fingerprint.



11..Compare and contrast the similarities and differences between AFIS and IAFIS including advantages and short-comings.

12. Compare and contrast between the three common print found at crime scenes, patent, latent, and plastic prints.



http://shs2.westport.k12.ct.us/forensics/04-fingerprints/fingerprint_parts.jpg

13. A fingerprint examiner notices the minutiae labeled letter A. Identify the minutiae (Look at the whole structure being pointed at).



Crime scene partial print



**generated through AFIS
as a possible match**

14. The partial print above was found at a crime scene and was entered into the latent print subsystem of AFIS. AFIS received a hit on the print. Determine if this is truly a match by comparing minutiae. Are they the same print or different prints?

Multiple Choice

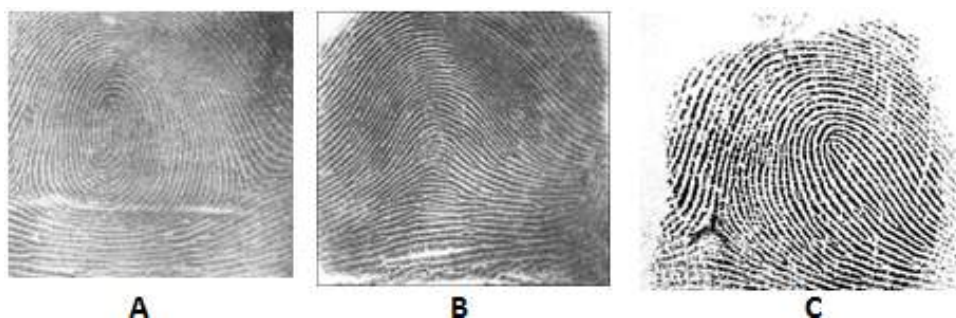
15. When using AFIS, what determines the final verification of a print's identity?
- A. After searching the database, the computer produces a list of prints that have the closest correlation to the search print. These are then examined by an expert.
 - B. The computer's search determines the final identity.
 - C. AFIS searches for a match & locates the print that matches the suspect's print.
 - D. AFIS searches against the database for a file of fingerprints that have a close resemblance to the print in question. Once the file is made, AFIS will examine and choose which print is an exact match with the suspect's print.
16. Analysts have devised three principles of fingerprints that comprise the distinctness and constancy of fingerprint identification. Which of the following is not one of the fundamental principles?

- A. A fingerprint remains unchanged during an individual's lifetime.
- B. A fingerprint is an individual characteristic; no two fingers have yet been found to possess identical ridge characteristics.
- C. A fingerprint is a reproduction of friction skin ridges found on the palm side of the fingers and thumbs.
- D. Fingerprints have general ridge patterns that permit them to be systematically classified.

17. Fingerprints are suspected on an envelope found at a recent crime scene. Which would be the best method to use to develop the prints? How does this method work?

- A. Fingerprint powder would be the best method. On paper, the powder adheres to perspiration residues. Once the print is visible, it may be lifted using tape and submitted as evidence.
- B. Cyanoacrylate ester would be the best method. Cyanoacrylate is heated and fumes adhere to the latent print on paper causing the print to appear white.
- C. Ninhydrin would be the best method. Ninhydrin is sprayed on a porous surface and binds to amino acids in perspiration, which produces a blue-purple color.
- D. Iodine fuming would be the best method. A porous material is placed in a chamber while iodine crystals are heated. The iodine fumes either adhere to fatty oils or residual water left from perspiration.

18. Place the following letters in order from least to most common fingerprint patterns.



- A. A, B, C
- B. C, B, A
- C. C, A, B
- D. B, A, C

19. What does the term *latent fingerprint* refer to?

- A. A visible print made by fingers touching a surface after they have been in contact with grease
- B. A fingerprint left on soft materials such as dust
- C. Any fingerprint discovered at a crime scene
- D. An invisible print made by the transfer of sweat or oils.

20. It is nearly impossible to change one's fingerprints. Some criminals have tried to obscure them. The most publicized attempt at obliteration was by a notorious gangster named John Dillinger. He tried to destroy his own fingerprints by applying a corrosive acid to them. Why was this not successful?

- A. The epidermis forms the pattern of the ridges on the surface of the skin. In order to change one's prints, the epidermis must be completely destroyed.
- B. The dermal papilla determines the pattern of the ridges on the surface of the skin. If this layer is damaged, ridge

patterns will grow back over time and a scar may also be produced, giving rise to another identifying characteristic.

C. The dermis develops the pattern of the ridges on the surface of the skin. In order to change one's prints, the injury must penetrate three layers to form a permanent scar.

D. The hypodermis must be damaged which will prevent the vessels to supply blood to the rest of the layers, thus damaging the prints.

CONCEPT 11

Unit 9 Soil and Glass Analysis

TEKS

(8) The student recognizes the methods to process and analyze trace evidence commonly found in a crime scene. The student is expected to:

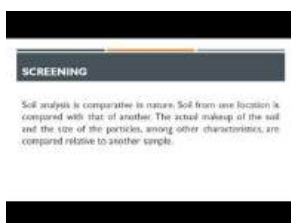
(A) demonstrate how to process and analyze trace evidence such as soil, glass, blood, paint, fibers, and hair collected in a simulated crime scene;

Objectives

In this chapter, topics will be explored such as:

- Soil composition
- Forensic analysis of soil
- Collection and preservation of soil evidence

Soil Composition



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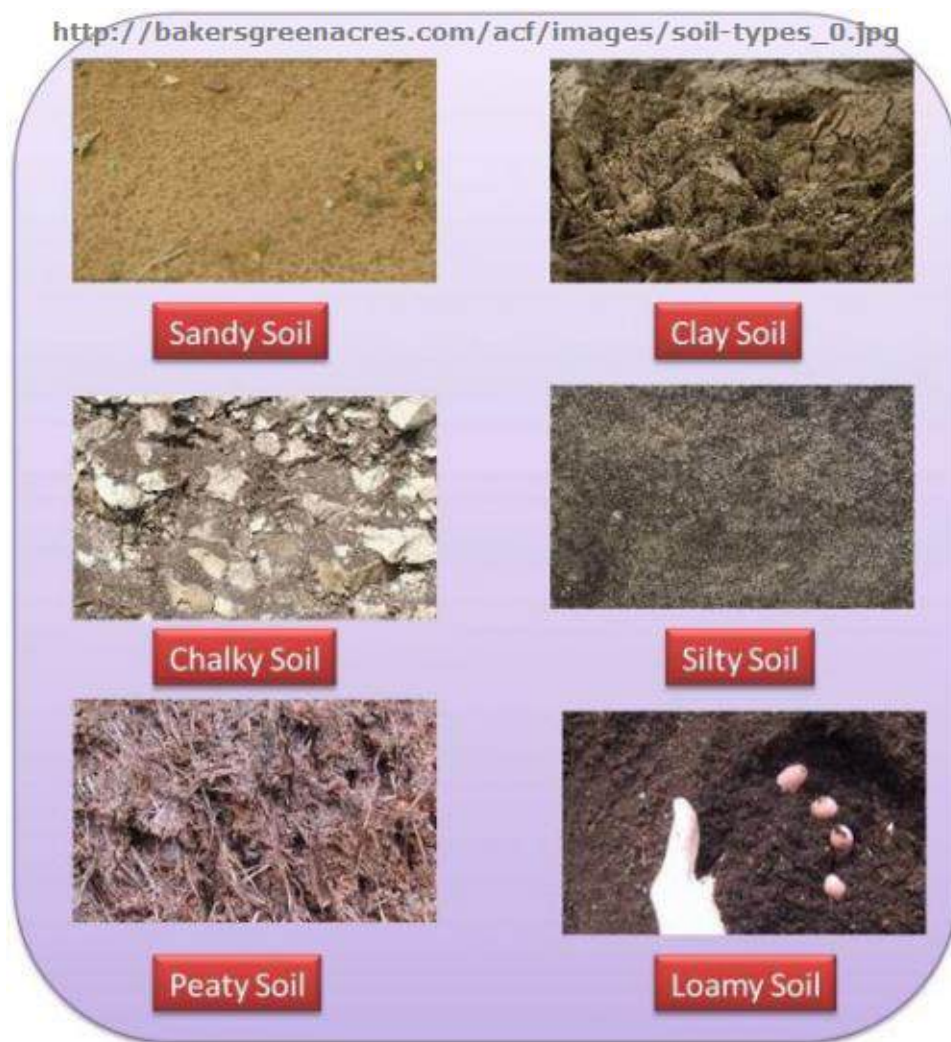
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Soil is known as material that can be natural and/or manufactured. Soil may be a mixture of natural items such as minerals, clay, broken down rocks, foliage, and organic remains, along with manufactured items such as particulates made of glass, cement, asphalt, bricks, cinders, paint, etc. Soil also comes in varying grain sizes such as **sand**, **silt**, and **clay**. **Sand** is the largest of the three with grains between 0.06 and 2.0 millimeters in diameter. It is commonly found in desert areas, beaches, and riverbeds. **Silt** consists of very fine particles intermediary in size between sand and clay. It is commonly the remains found in riverbeds. **Clay** is the smallest size of the three with grains smaller than 0.002 millimeter in diameter. Clay is found all over the world and has been used by many civilizations to make pottery and/or bricks to build homes.



There are three subcategories of soil called **peat**, **loam**, and **chalk**. **Peat** is made of at least 20% decaying organic material and is found in wet areas, such as bogs. Peat is known for retaining large amounts of water and is used as a fertilizer for that reason. **Loam** is a mixture of sand, silt, and clay and is found in many locations across the world. This soil type is the most fertile and is best for agriculture. **Chalk** tends to be very alkaline and may be found below the top layer of soil.

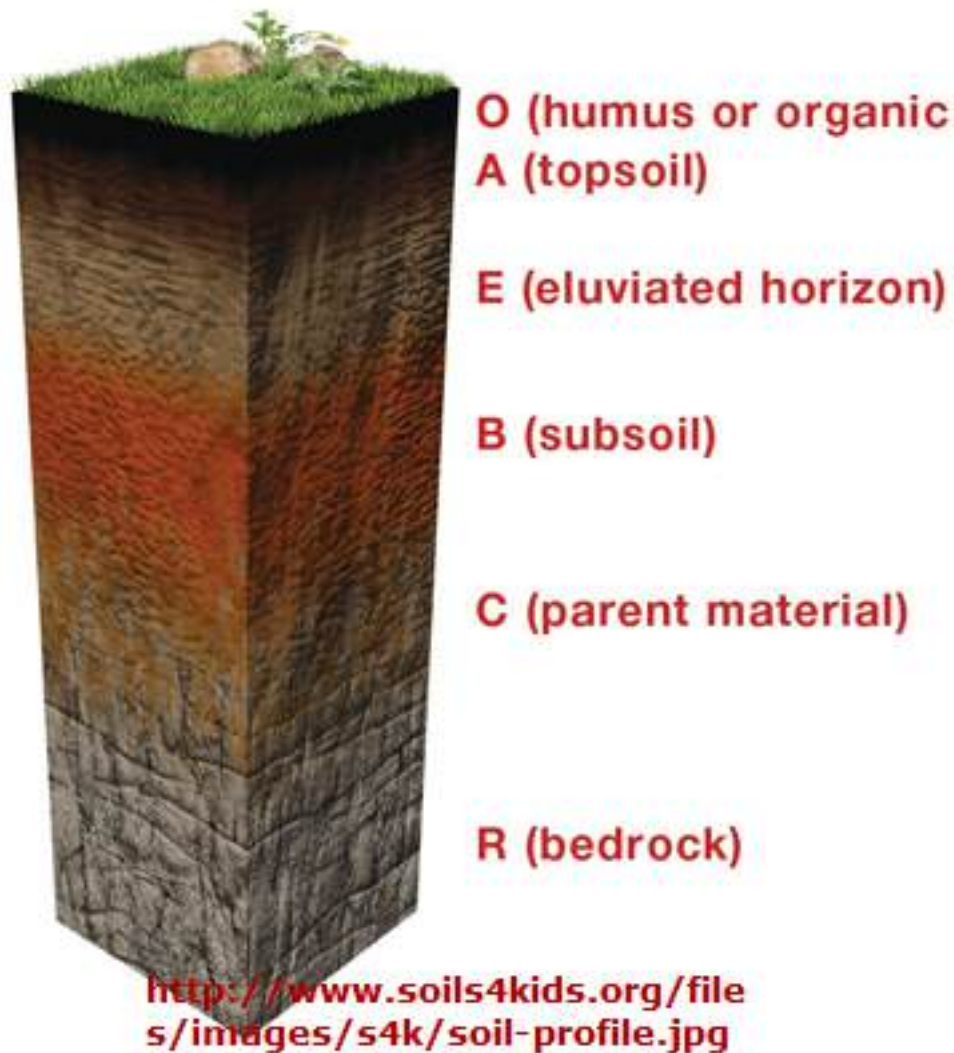


Natural occurrences such as temperature, wind, rainfall, erosion, etc. play an important role in the formation of soil. Therefore, due to the varying characteristics of separate regions, there may be very different physical and chemical compositions of the types of soil found. This will help to provide valuable comparison points within soil samples originating from similar and different locations.

Soil Horizons

Soil formation occurs in layers called **horizons** that have very different characteristics from one another. The O layer is commonly termed the **humus** layer and is known for having an abundant amount of decaying material. The A horizon is called topsoil and is very dark in color due to a mixture of the soil with minerals. Roots will proliferate through this layer. The E layer consists of sand and silt and is very light colored. **Leaching** tends to occur in this area. These types of soil are known for not retaining water. As water passes through, it carries away valuable minerals and/or clay, stripping away valuable nutrients. The B layer holds clay and a mineral stripped away from the upper layers, and is referred to as the subsoil. The C horizon has rocks that have been broken apart some. Roots

will not extend into this layer. The last layer is the R horizon and is known for being rock-hard and solid. For the most part, soil evidence usually involves the O and A horizons.



Soil Analysis



MEDIA

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The first step in soil analysis lies in visually comparing two samples. The color is examined to determine if the samples are from the same or different origins. It is of utmost importance to examine these samples when they are dry, due to the fact that wet samples may appear quite darker than dry samples. There are thousands of different soil samples in existence, so color is always a great stepping stone when comparing samples. A color chart is used to help distinguish the color of the soil in question.



The grain sizes are also visually inspected by using the **sieving** method. A soil sieve is used to separate out the different particles by their relative size. This helps to classify the type of soil obtained.





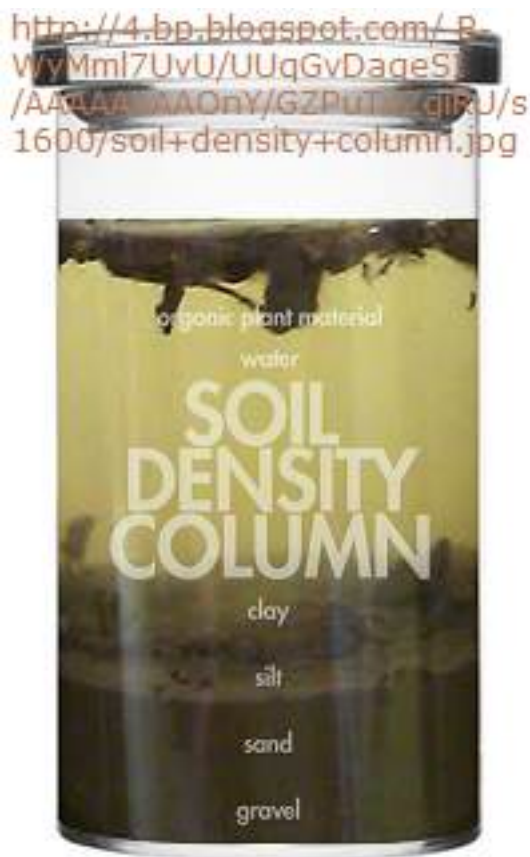
Figure 1

<http://mvascientificconsultants.com/wp-content/uploads/2011/05/soil-sifting-analysis-by-light-microscopy.jpg>

Microscopic exam is the next step in soil analysis. Using different magnifications may reveal very different, but important information. Low-power, for instance, will reveal if any organic material is present from plants or animals along with manufactured materials. High-power will help to discern the types of rocks or minerals present in the sample. **Rocks** are very unique in that there are many minerals that make up the composition of the rock. Not only that, but there are so many special combinations that help to make rocks distinctive from one another. In order to discern rocks from each other, an expert will likely compare the grain size along with the mineral matter. **Minerals** are crystals that vary in many aspects such as color, clarity, shape, density, and refractive index. Many are rare, but a few may be common to certain areas' soil contents. A **geologist**, who studies the earth, will likely be called upon in order to help investigators determine where a soil sample may have originated from and whether they can link a suspect to the actual crime scene.



Soil may also be analyzed through a density column. Dense liquids are placed at the bottom of the column and less dense liquids on top. When the soil sample is placed in the density column, the particulates will sink into the layer where the density is equal. When the soil samples are compared through these columns, similar soils will have similar patterns within the column. Dissimilar soils will vary greatly from one another.



MEDIA

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Different soils also have different moisture contents. Some soils are naturally tackier than others, whereas others tend to be very dry. This can be helpful in discerning the probability that two samples came from the same area or not. Chemical testing may also be carried out to determine the pH or the mineral content of soil. X-ray diffraction is a more technologically advanced way to compare soil samples. A sample is crushed and tested. A pattern will appear depending on the chemical and mineral contents found within the sample. The patterns from the suspect sample and the crime scene are then compared to determine if there is correlation between the two.



Soil Collection and Preservation

- Soils are collected at different areas within a 100-yard radius of the crime scene, and from the crime scene, and at any alibi locations as well.
- If the soil sample is the topsoil found on the suspect, then the sample collected for comparison must be the topsoil as well.
- Two to four tablespoons collected at each location is sufficient to submit to the laboratory.
- Each location must be packaged separately into plastic vials and must be labeled with pertinent information to specify where exactly the sample was collected from.
- A sketch may be drawn to indicate where each sample was obtained. Photographs may also be taken to show the relative location of the samples taken.
- If soil is found stuck on an object, submit the whole object. The soil sample may be removed by the lab personnel once it arrives at the lab.
- If soil is found on clothing, wrap the clothing in paper bags, being extra careful to not let any particles fall off the item.
- If a chunk of dirt is found, submit the entire piece.
- In an accident, soil left at the crime scene and soil samples from the car's body are collected and preserved separately for analysis at the laboratory.

TEKS

(8) The student recognizes the methods to process and analyze trace evidence commonly found in a crime scene. The student is expected to:

- (A) demonstrate how to process and analyze trace evidence such as soil, glass, blood, paint, fibers, and hair collected in a simulated crime scene;
- (B) compare and contrast the composition of various types of glass fragments such as soda lime, borosilicate, leaded and tempered;
- (C) determine the direction of a projectile by examining glass fractures;
- (D) define refractive index and explain how it is used in forensic glass analysis;
- (E) describe the instrumental analysis of trace evidence such as microscopy and spectrometry;

Objectives

In this chapter, topics will be explored such as:

- Defining glass
- Glass types
- Glass analysis
- Fracture patterns/projectile directions
- Collection and preservation of glass evidence

What is Glass?



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Glass is made by mixing together sand and other minerals that are heated at temperatures at or above 1700°C. Silica (silicon dioxide) from sand is the major ingredient along with lime (calcium oxide) and sodium oxide. When sand and minerals are melted, the ingredients turn into liquid glass. As the liquid cools, it starts to form the hard product known as glass. The atom arrangement in the hard glass product is random and imparts an irregular atomic structure which makes glass break in many different fashions.

Types of Glass

There are many types of glass produced. For the most part, forensic scientists deal with the analysis of **soda-lime glass**, which is used to make many items such as windows and bottles. This type of glass is also referred to as float or plate glass. When broken, this glass typically will break into separate, single pieces. Metal oxides used to make soda-lime glass are calcium, sodium, aluminum and magnesium. Because of this glass being widely used, it is readily recyclable.

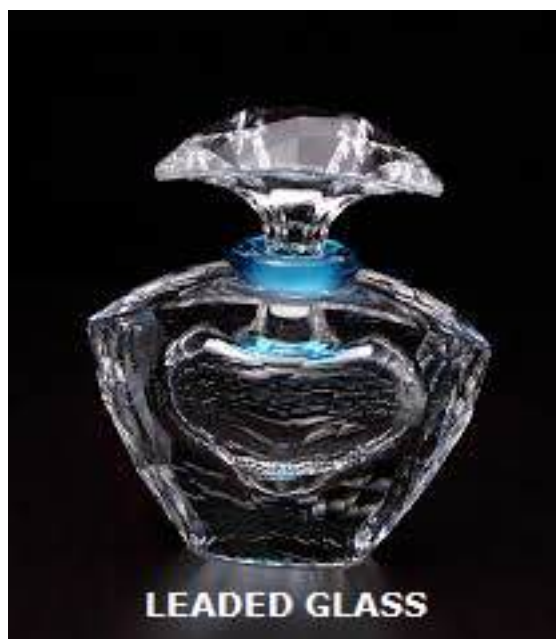


Soda-lime Glass Bottles

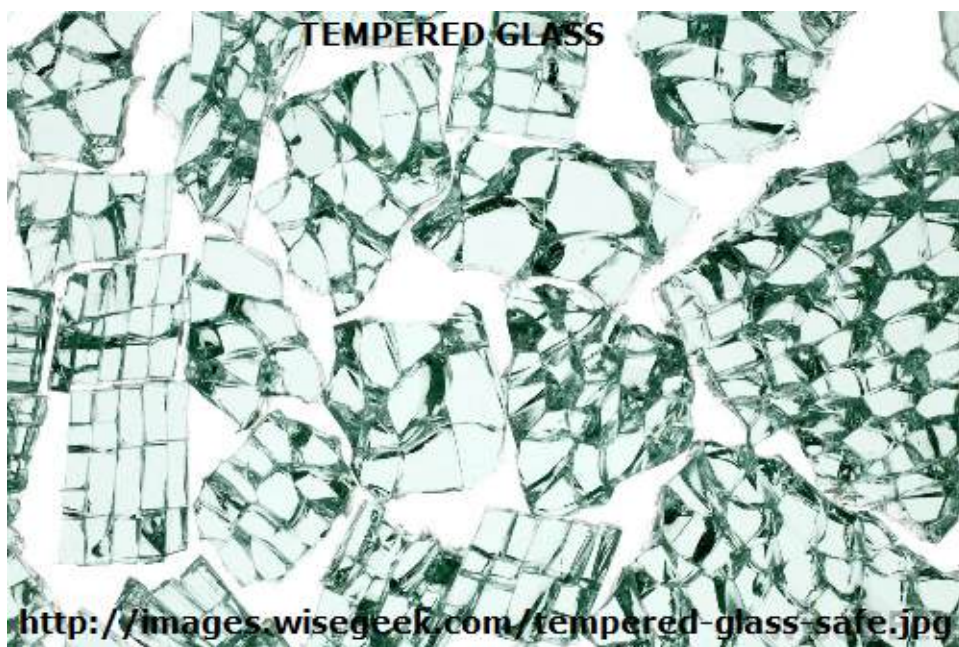
Borosilicate glass is made by replacing the calcium oxide with another metal oxide called boron oxide. This addition allows the glass to withstand temperatures, whether hot or cold, that most other glassware could not. This glass can be used for baking such as the brand name known as Pyrex, laboratory glass known as Kimax, or to make headlights for vehicles.

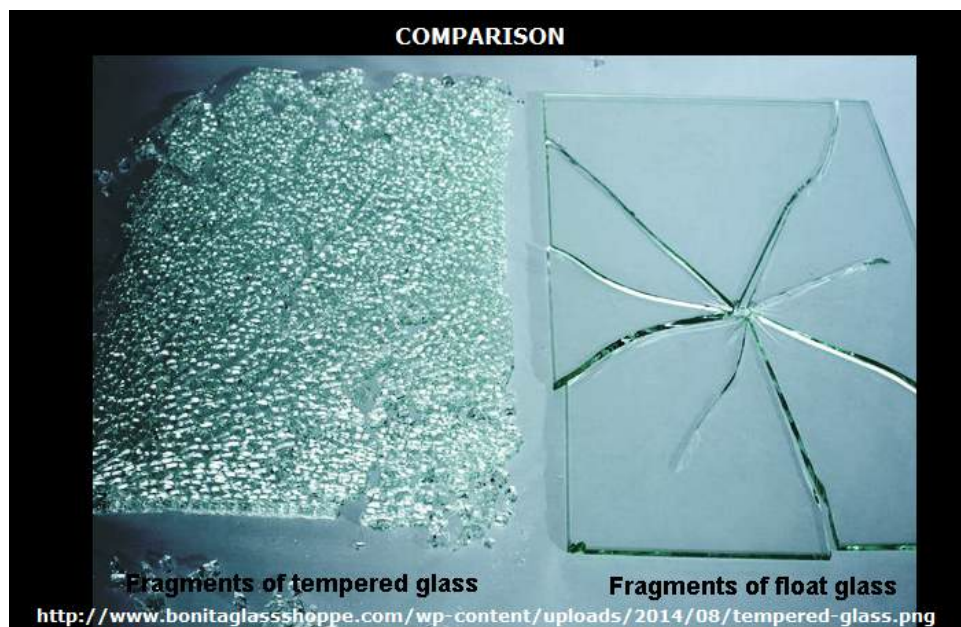


Leaded glass is a denser glass due to the addition of lead oxide instead of calcium oxide. It is used to make art glass and top quality glassware, known as crystal. Light waves are bent as they travel through the glass, giving this glass its characteristic sparkling qualities.



Tempered glass is much more durable than regular soda-lime glass. The way that it gains its sturdiness is by the swift heating and cooling that it undergoes, which adds stress to the glass. This glass behaves differently when broken. Tempered glass will break off into small fragments or small aggregates of glass, which is a safety feature of this glass type. Tempered glass is used to make the side and back windows in vehicles.





Laminated glass is used to make vehicle windshields. This is also known as a strong type of glass due to the addition of a plastic layer between two sheets of glass. If the glass is ever to break, the plastic layer in between keeps the glass from breaking into solitary fragments, thus holding the glass in place, which is a great safety feature.

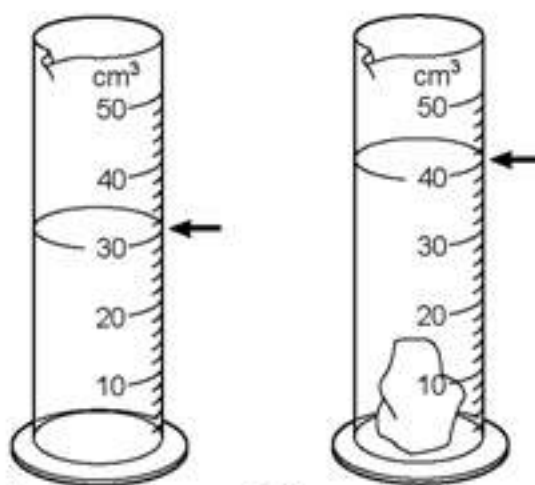


Glass Analysis

An investigator is pleased when he or she may find a glass sample that completes a piece of a puzzle. When this happens, **individual characteristics** are conveyed. The asymmetrical breaks and/or striations on the broken glass must match to show that they do belong to the original piece. Frequently, glass is shattered and the pieces are too small to even begin to try to piece anything together. When this occurs, it is important to try to determine **class characteristics** of the samples found. Class characteristics will not tell us that a glass fragment belongs to a specific source, but will communicate information that will reveal facts such as the type of glass an investigator can center on for investigative purposes. Density and refractive indices are used to distinguish glass particles' class characteristics. This will help to compare and exclude different types of glass ultimately.



Density is a straightforward calculation, taking a sample's mass and dividing it by its volume. Glass particles may be weighed on an electronic balance to determine the mass. A graduated cylinder is filled with a fixed amount of water. The glass sample is placed into the graduated cylinder. The amount of water that is shifted will be the volume of the sample. This is called the **displacement method**. For example, let's say that a graduated cylinder is filled with 30 mL. The glass is placed into the water. The water rises to 40 mL. The volume of the sample is the final volume minus the initial volume, which is 40 mL- 30 mL, which is a final volume of 10 mL. The density is now calculated by taking the mass from the electronic balance and dividing it by the volume. The units are represented as grams per milliliter.



https://www.patana.ac.th/secondary/science/anro/physics/underwaterphysics/images/vol_density.png

A **flotation comparison** may also be done, which is also based on density. A piece of glass from the crime scene is dropped into a liquid such as bromobenzene, which has a density of 1.52 g/mL. It sinks to the bottom, meaning that

the glass piece is denser than the bromobenzene. A different liquid, such as bromoform with a density of 2.89 g/mL is now used and is released one drop at a time until the glass neither sinks nor floats, but stays balanced in one place underneath the surface of the liquid. This will be the ultimate density of the glass fragment. Now, a piece of glass is obtained from a suspect's windshield and is tested as mentioned above. If the sample reaches that same balance underneath the surface of the liquid, as above, with the same amount of drops of the denser liquid bromoform, both glass densities are the same. A density meter may be used to obtain an accurate density measurement. If one is not available, the density may be calculated by using the following formula:

$$d = \frac{X (2.89) + Y (1.52)}{X+Y}$$

X and Y are the volumes of the liquids used and the numbers in parentheses are the densities of the liquids.



MEDIA

Click image to the left or use the URL below.

URL: <http://www.ck12.org/flx/render/embeddedobject/175605>

Have you ever noticed that when you stick an object into a glass containing water, the object appears in a different place other than the location in which you actually placed the object? This shows how a beam of light bends in a different medium, such as how the spoon appears in air versus water which is due to a change in speed. This refracting, or bending of light is known as **refraction**. The refraction will change due to the different densities of the two mediums.



The **refractive index** is used to consider how light bends as it goes through the different mediums. If light can pass through a certain substance or item, it will have its own refractive index. This is calculated by dividing the speed of light in a vacuum by the speed of light in that medium. The speed of light in a vacuum is 300,000 km/s. As the density of the medium increases, the speed of light through a substance will decrease, vice versa. The refractive index of a vacuum is 1.0 km/s, air is 1.0008 km/s, and glass is 1.47-1.61 km/s depending on the type of glass. Air is denser than that of a vacuum, so the speed of light traveling through air will occur a bit slower than the traveling through a vacuum. Glass is denser than both air and a vacuum, so the speed of light will travel slower than those two mediums.

Liquids have their own respective refractive indices. When a piece of unknown glass is placed into a liquid that possesses a different refractive index, the glass will still be able to be seen. When the liquid has the same refractive index, the glass will disappear because it refracts light at the same angle as the liquid.



In order to determine the refractive index of a fragment of glass, various liquids with known refractive indices will be used. The liquids are placed in separate containers. The crime scene glass sample will be placed in the liquid to see if it disappears. If the glass fragment is visible (the Becke line is present), it does not have the same refractive index. At the point in which it disappears (the Becke line disappears), the refractive index of the liquid and the glass fragment are the same. The same thing will be done with the suspect glass sample. Glass fragments can help tie a suspect to a crime scene. If the refractive index of an unknown sample matches a sample taken from a suspect, it will strongly place the suspect at the crime scene. This can also help to yield clues as to the type of glass that has been found, but should not rely solely on this method because some types of glass may have overlapping refractive indices.

Glass Type	RI	Common Liquids	RI
Pyrex	1.47	Methanol	1.33
Headlight glass	1.47-1.49	Water	1.33
TV glass	1.49-1.51	Isopropyl alcohol	1.37
Window pane glass	1.49-1.51	Olive oil	1.47
Bottle glass	1.51-1.52	Glycerin	1.47
Eyeglasses	1.52-1.53	Castor oil	1.48
Quartz	1.54-1.55	Clove oil	1.54
Leaded glass	1.56-1.61	Cinnamon oil	1.62

Microscopes may also be used to view glass fragments and may offer clues as to which type of glass the sample originated from. For example, float glass will appear flat. A fragment from a wine glass will be faintly bowed. Manufactured bottles will have microscopic defects present. High-powered microscopes with heated stages may also be used to examine the refractive index of glass samples collected. Scanning electron microscopes may reveal the elemental make-up used such as the Si, Na, Ca, Mg, K used to manufacture the glass. The upside of using this method for analysis is that diminutive samples can be examined, as small as 50 micrograms.

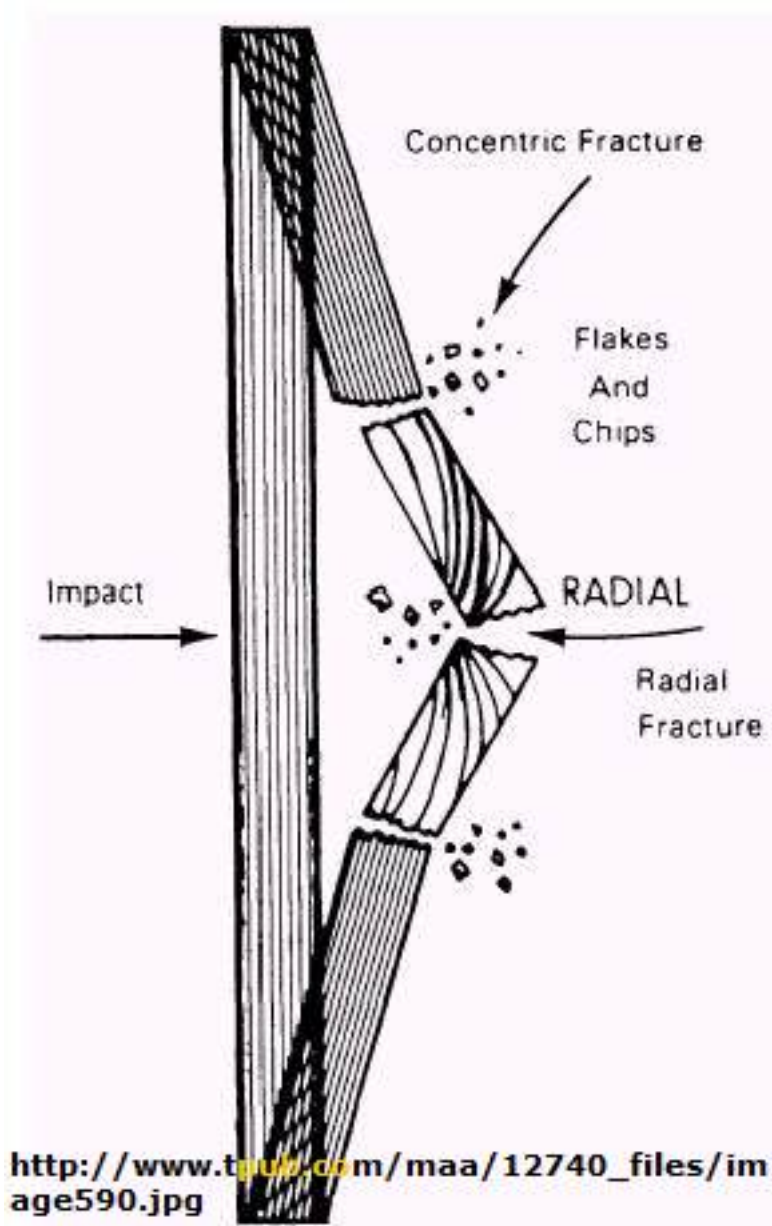


Differences in the density and refractive indices of two glass samples prove that they are completely different samples. Commonalities between the samples show that they could potentially have come from the same source. How sure can one be to ultimately say that these two samples came from the same exact glass? The FBI possesses a database that has the values for many glass types/samples and how likely they are to be found in the U.S. After the density and refractive index values are obtained by an examiner, the database may be referenced to check the likelihood of finding this glass type. The more likely the glass is found, the less probative value it has. The rarer the sample, the higher probative value it will have.

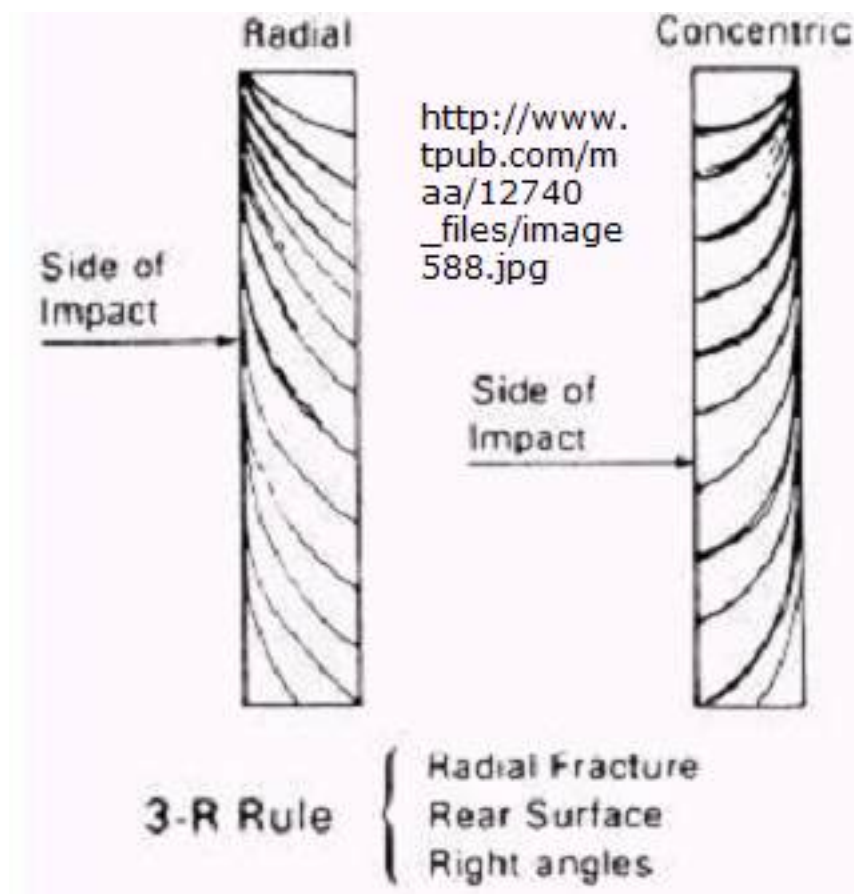
Fracture Patterns and Projectile Directions

Glass may be flexible due to the slight elasticity that it retains. When that limit is surpassed, the glass will begin to break. These fractures will provide valuable information such as the direction an object hit the glass, which impact hit first, and the speed of the impact.

When glass is broken, the first fractures to form are called **radial fractures**. They will start in the middle of where the glass was hit and spread out in lines from there. These breaks are known to occur on the opposite side from which the glass was actually hit. The next fractures to form are the **concentric fractures**. These will form circles around the impact and will occur on the side from which the glass was hit. Knowing this information will help an investigator decipher which side of the glass was the side that received the initial blow. If for instance a bullet hits glass, it will produce less concentric cracks. If a rock hits glass, it will form more concentric circles. This is due to the amount of speed an object has behind it.



Cracks may also help to reveal the impact side by examining the stress marks of the breaks. On a radial fracture, the perpendicular side will be the side that did not receive the impact and the parallel side will be on the impact side. Concentric breaks will show the opposite. The perpendicular side will be on the impact side and the parallel side will be on the side not impacted.



If a bullet was the culprit when it comes to glass breaking, it will cause a small piece of glass, or multiple small pieces of glass in front of the bullet to exit on the opposite side from the initial impact. The entrance hole thus will be smaller than the exit hole. When multiple shots are fired, it is quite easy to determine the order of the shots. Radial fractures from the second shot will end into the radial fractures from the first impact. If there happens to be a third shot, its radial fractures will end into the radial fractures from the second impact, and so on. In the picture shown below, the shot on the left was the initial shot, followed by the right.

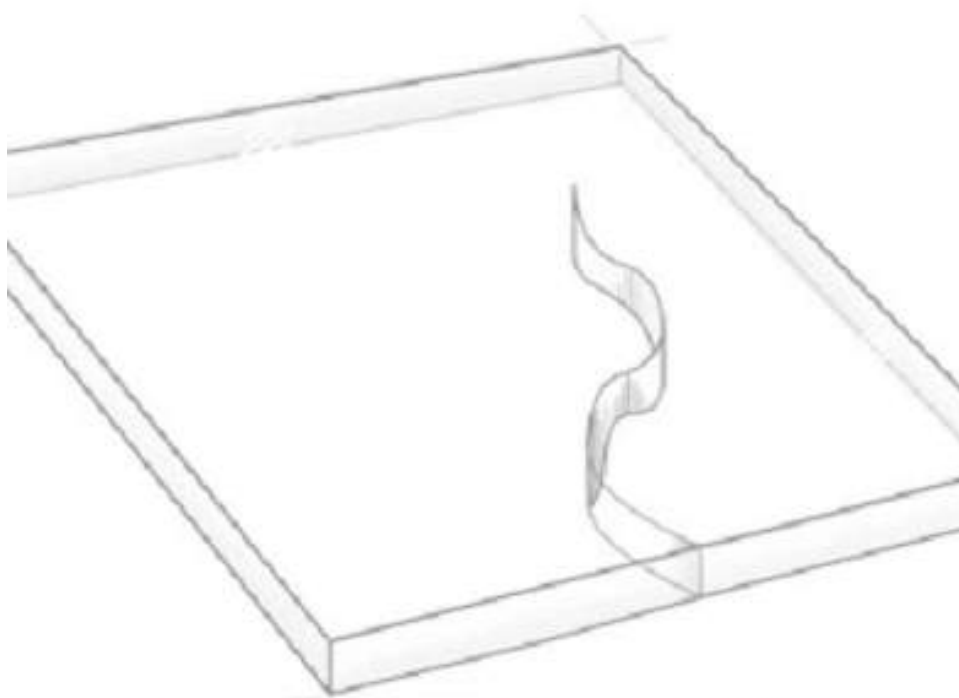


Glass may also help to reveal the location from which the shot was fired, showing where the shooter was located. If there is a perfectly round hole, it shows that the shooter was standing perpendicular to the glass that was shot. If the person shot at an angle from the right side, the hole in the glass will be oval shaped and will leave shards of glass on

the left side and vice versa if the shot was taken at an angle on the left side. Sometimes, when the shooter is close enough to the glass that he or she shot, the glass will **backscatter**. When a shot is fired, most of the glass will exit on the opposite side. When there is enough force and also because glass is known to possess elasticity, some glass will shatter back to the original impact side. This may leave some shards on the suspect that may help to link them to the crime scene.

There are times in which none of the former mentioned will produce a crack in glass. If there is a fire present, it may make glass fracture and will look completely different from a typical bullet penetrating glass, conveying radial and concentric fractures. It will appear curved, will not contain an initial impact fracture and will be smooth to the touch. The glass will also tend to break on the side it is exposed to higher degrees of heat.

Heat Fracture



https://ggamesau.files.wordpress.com/2013/07/thermal_stress_fracture_low2.jpg?w=327&h=327&crop=1



- Photographs with scales should be taken of all glass samples before the glass is to be moved.
- Make every attempt to collect any and all glass fragments.
- It is important to prevent contamination of glass samples.
- Care must be taken to ensure that no glass fragments are lost when collecting and packaging them.
- The largest fragments that can be easily seen must be collected.
- Be able to differentiate the inside versus the outside surface of a glass sample.
- Do not combine any known and unknown samples together. Keep them separated.
- Glass should be removed from a broken glass pane. If many glass panels are involved, it is important to diagram where each sample was removed from the corresponding window panes.
- Pay close attention to the glass sample and seek to find any other evidence piece connected to the glass, such as fibers or blood.
- Send in all glass evidence found on the suspect along with the glass found at the crime scene.
- Separate the glass by size, color, and texture.
- Package samples separately to avoid contamination.
- Glass should be packaged in sturdy containers to prevent breakage.
- Inspect clothing or tools used to break the glass for any fragments.
- Individual clothing items with glass fragments attached to them should be packaged separately.

Chapter Summary

- Soil may be a mixture of natural items such as minerals, clay, broken down rocks, foliage, and organic remains, along with manufactured items such as particulates made of glass, cement, asphalt, bricks, cinders, paint, etc.
- Soil comes in varying grain sizes such as sand, silt, and clay.
- There are three subcategories of soil called peat, loam, and chalk.
- Natural occurrences such as temperature, wind, rainfall, erosion, etc. play an important role in the formation of soil.
- Soil formation occurs in layers called horizons that have very different characteristics from one another.
- Soil analysis includes color comparison, comparing grain sizes, microscopic examination, density columns, comparing moisture contents, chemical testing for pH or mineral content, and x-ray diffraction.
- Collecting and packaging evidence is of utmost importance when dealing with soil.
- Glass is made by mixing together sand and other minerals that are heated at temperatures at or above 1700°C.
- Soda-lime glass is used to make many items such as windows and bottles and is also referred to as float or plate glass.
- Borosilicate glass is made to withstand temperatures, whether hot or cold, that most other glassware could not.
- Lead glass is used to make art glass and top quality glassware, known as crystal.

- Tempered glass is used to make the side and back windows in vehicles.
- Laminated glass is used to make vehicle windshields.
- An investigator is pleased to be able to fit two pieces of glass together to convey individual characteristics. Most of the time glass pieces are so small that they can't be put back together.
- Class characteristics will not tell us that a glass fragment belongs to a specific source, but will communicate information that will reveal facts such as the type of glass an investigator can center on for investigative purposes.
- Density of a glass sample may be determined using the displacement method or flotation comparison.
- The refractive index is used to consider how light bends as it goes through the different mediums. If light can pass through a certain substance or item, it will have its own refractive index.
- If the refractive index of an unknown sample matches a sample taken from a suspect, it will strongly place the suspect at the crime scene. This can also help to yield clues as to the type of glass that has been found, but should not rely solely on this method because some types of glass may have overlapping refractive indices.
- Microscopes of various sorts such as high-powered microscopes with heated stages and scanning electron microscopes may also be used to view glass fragments and may offer clues as to which type of glass the sample originated from.
- The FBI possesses a database that has the values for many glass types/samples and how likely they are to be found in the U.S.
- Radial fractures start in the middle of where the glass was hit and spread out in lines from there.
- Concentric fractures will form circles around the impact and will occur on the side from which the glass was hit.
- When examining stress marks of breaks, on a radial fracture, the perpendicular side will be the side that did not receive the impact and the parallel side will be on the impact side. Concentric breaks will show the opposite.
- If a bullet penetrates a glass, the entrance hole thus will be smaller than the exit hole.
- To determine the order of shots, radial fractures from the second shot will end into the radial fractures from the first impact.
- Glass may also help to reveal the location from which the shot was fired, showing where the shooter was located.
- When there is enough force and also because glass is known to possess elasticity, some glass will shatter back to the original impact side. This may leave some shards on the suspect that may help to link them to the crime scene.
- Heat fractures will appear curved, will not contain an initial impact fracture and will be smooth to the touch. The glass will also tend to break on the side it is exposed to higher degrees of heat.
- Collecting and packaging evidence is of utmost importance when dealing with glass.

Review Questions

Short Answer

1. Compare and contrast radial and concentric fractures including information such as their definition, which forms first, and on which side they will form.
2. A crime scene investigator is sent to a crime scene to collect evidence samples. Soil is the first thing that is spotted that looks different from the soil present in the vicinity. A tablespoon of the soil that looks different along with a tablespoon of the soil in the vicinity are collected. The investigator even goes above and beyond, collecting soil samples one foot deep within the earth at the crime scene. The soil that looks different is packaged into a plastic vial, and the other soil in the vicinity and the sample taken from one foot within the earth are packaged into the same vial, since they are essentially the same exact soil. All vials are labeled before they are sent off to the lab. What, if anything, went wrong when collecting and packaging the evidence?

3. You are examining a broken glass sample from a house that was burglarized. A suspect was obtained and his clothes were collected and sent to you to examine as well. You find small glass fragments on the suspect's clothing. How would you test these samples using refractive indices?
4. What are the differences between the various types of glass such as soda lime, borosilicate, leaded, tempered, and laminated glass, including components used to make them and for what the glass is typically used?



5. The picture above shows two bullet holes that penetrated glass at a crime scene. Which was the initial gunshot? How can you defend your decision?

True or False

6. True or False: Primary fractures are formed on the same side of impact and form circles around the impact hole of the bullet.
7. True or False: Borosilicate glass is made of calcium oxide which allows the glass to withstand temperatures that most other glassware could not.
8. True or False: A microscopic exam may help to reveal information when analyzing soil evidence. Low-power, for instance, will reveal will help to discern the types of rocks or minerals present in the sample. High-power will reveal if any organic material is present from plants or animals along with manufactured materials.

Multiple Choice

9. Glass is placed in various liquids with different refractive indices and viewed under a microscope. What does it mean if there is a Becke line present?

- A. The Becke line is an indicator to show up to where the liquid should be filled in order to fully submerge the glass fragment.
- B. The Becke line shows that there is a difference in refractive indices between the glass fragment and the liquid medium being used. It shows that they do not share the same refractive index.
- C. The Becke line is part of the objective lens of the microscope. It shows how the stage should be moved in order to line up the glass fragment with the Becke line in the objective to bring the glass sample into full view.
- D. The Becke line appears when the refractive indices are similar.

10. What is the first step in analyzing soil?

- A. Determining moisture content
- B. Microscopic Examination
- C. Color comparison
- D. Deciphering grain size

-

CONCEPT

12

Unit 10 Firearms and Tool Marks

TEKS

(14) The student evaluates bullet and tool mark impressions in a criminal investigation. The student is expected to:

- (A) explain the individual characteristics of tool marks;
- (B) describe the mechanism of modern firearms;
- (C) recognize characteristics of bullet and cartridge cases;
- (D) describe the composition and method of analysis for gunshot residue and primer residue;
- (E) recognize the type of information available through the National Integrated Ballistics Information Network.

Objectives

In this chapter, topics will be explored such as:

- History
- Firearm mechanism
- Firearms and physiology
- Ammunition/types of bullets/cartridge cases
- Firearm fabrication/rifling
- Comparing bullets and cartridge cases
- IBIS and NIBIN
- Gunshot and primer residues
- Tool marks
- Evidence collection and packaging

History

Firearm identification centers on studying marks on bullets and shell casings to determine if these items were fired from a specific gun. Rifling dates back to the 1400-1500's. **Rifling** is known to help with the rotation of the ammunition as it travels through the barrel of the firearm. It took a few centuries to reveal that these markings caused by the barrel would help identify which firearm it was shot from.

In the early 1900's, toolmark and firearm examination became accepted generally by law. In 1930, the Scientific Crime Detection Laboratory was developed along with the creation of the Federal Bureau of Investigation in 1932. Not only the U.S., but many other countries started to take notice of firearm examination and began to create their own labs to offer these services.

In the 1960's, there was a prevalent use of firearms in crimes within the United States. The AFTE, the Association of Firearm and Toolmark Examiners, was established in 1969 in Chicago, Illinois. The science had progressed, and near the end of this century, many forensic scientists became well-versed in this subject matter.

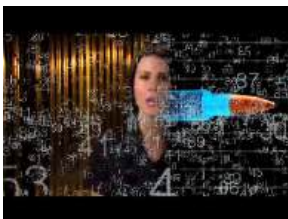
Technological advances have assisted these scientists develop and improve their craft. Comparison microscopes have proven to be a valuable tool when examining crime scene bullets and shell casings and comparing them to standard samples, side-by-side. Computers and software such as Drugfire and IBIS have helped to secure digital images of bullets and casings that can then be crossed against a database to reveal if there is a match. These systems are integrated into NIBIN, which is the National Integrated Ballistic Information Network, which is a program run by the ATF (the Bureau of Alcohol, Tobacco, Firearms, and Explosives) and FBI. Law enforcement may then search for evidence matches not only within their jurisdiction, but adjacent jurisdictions, and anywhere throughout the country. This system is comparable to AFIS, which is an automated system used for fingerprints.

Mechanism of Modern Firearms

Handgun Parts and Functions



The picture shown above is that of a revolver. The **cylinder** houses **the live cartridges** (ammunition) into each of its separate chambers. Once the **hammer** has been cocked, its sole duty is to hit the **firing pin**. The pulling of the **trigger** will put the hammer into a forward motion, hitting the firing pin, which strikes the **primer** on the back of the cartridge, which then ignites the gunpowder, which causes a pressure buildup and fires the bullet from the **barrel** of the gun. The **shell casings** (same as cartridge cases) will be left in the chamber until the shooter manually removes them. The **grip** is simply used to hold the firearm.



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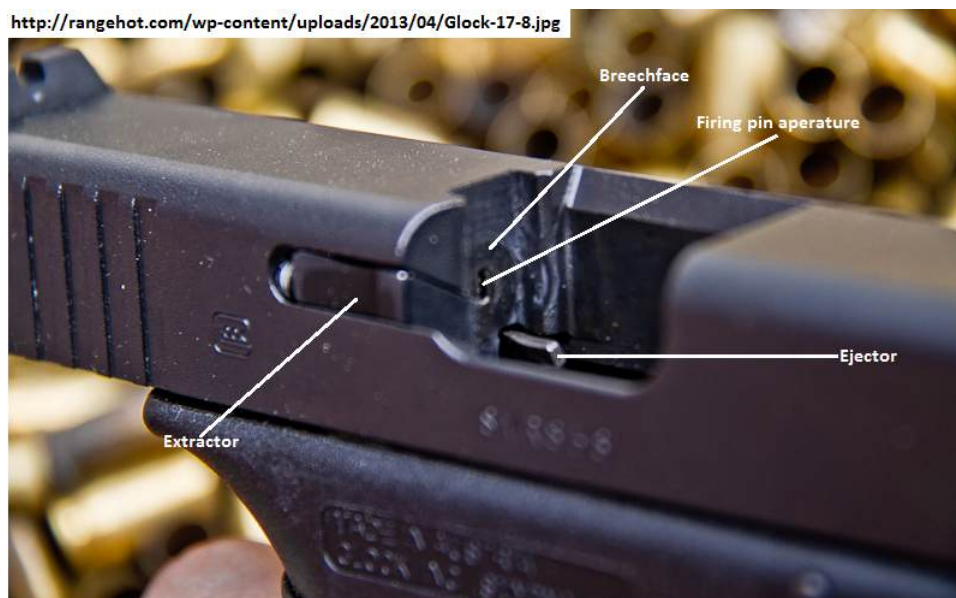
The picture below shows the inside of the revolver. The **firing pin aperture** is the hole in which the firing pin passes through in order to hit the primer on the back of the cartridge, which sets the bullet in motion. The **breechface** is where the back of the cartridge sits before it is fired. The breechface gets imprinted onto the back of the cartridge, which serves as a comparison point to determine whether a cartridge was actually shot from a specific firearm.



The picture shown above is a semiautomatic handgun. The **magazine** is loaded with live cartridges. It is then placed into the **grip**, used to hold the firearm. The **slide** is pulled in a rearward fashion in order to cock the hammer. The **trigger** is pulled, which forces the **hammer** to come in contact with the **firing pin**, thus hitting the **primer** as mentioned above. The **barrel** imparts the spin on the projectile. The **extractor** is responsible for withdrawing the shell casing from the barrel so that it does not propel through the barrel with the bullet that has been set in

motion. Many manufacturers have made the **safety** a set part of the firearm. When it is set, it will not fire if the trigger is pulled. The gun will only work if it is not in the safety mode. This has helped to save many curious children from killing themselves.

On the interior of the gun, some parts are similar to those mentioned on the revolver. The firing pin aperture and breechface serve the same purpose. When the gun has been fired, and the slide is traveling backwards to its original position, the **ejector**'s duty is to expel the fired cartridge case from the momentary opening in the slide. As mentioned in the previous paragraph, the **extractor** keeps the shell casing from traveling through the barrel.



Types of Firearms and their Physiology

Revolvers

There are many different types of firearms that have minor differences between them. A revolver may either be single action or double action pistols. These types of guns do not have magazines. They require the handler to open the cylinder and load separate pieces of ammunition into the corresponding chambers. **Single action revolvers** require the shooter to manually cock the hammer. The gun is now ready to be shot. All that is left is for the shooter to place slight pressure on the trigger to bring the hammer in motion to fire the bullet. Once all rounds have been shot, the shooter must manually open the cylinder to release the shell casings from the chambers. **Double action revolvers** take care of two actions at one time. With one pull of the trigger, the hammer will be cocked and released, firing the bullet.



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Semiautomatic Handguns

A **semiautomatic handgun**, also known as an auto-loading handgun, requires ammunition to be loaded into a **magazine** (simply used to house the ammunition), and then the magazine is inserted into the firearm's grip. It needs the action of the shooter in order for the first cartridge to be loaded into the barrel of the gun. This is called **cocking** the hammer. All that is left is pulling the trigger (single action) to release the bullet from the barrel and successively

releases the spent casing from the slide. Upon the release of the ammunition, a new cartridge is automatically loaded into the gun for subsequent firing, not needing the shooter to cock the handgun anymore.

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Rifles

Rifles are so named because the bore is rifled, which means that there are spiral grooves present that help make the shot fired more accurate. There are different types of rifles that may be used for warfare, hunting game, and

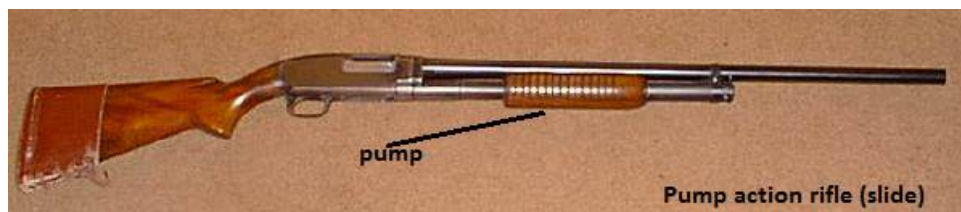
shooting sports. They have better accuracy and can be shot at longer ranges, which makes this type of gun better than a shotgun. Some examples of rifles are bolt action rifles, lever action rifles, slide or pump action rifles, semi-automatic rifles, break action rifles, and falling block action rifles. The video that ensues will describe the differences between these rifles.



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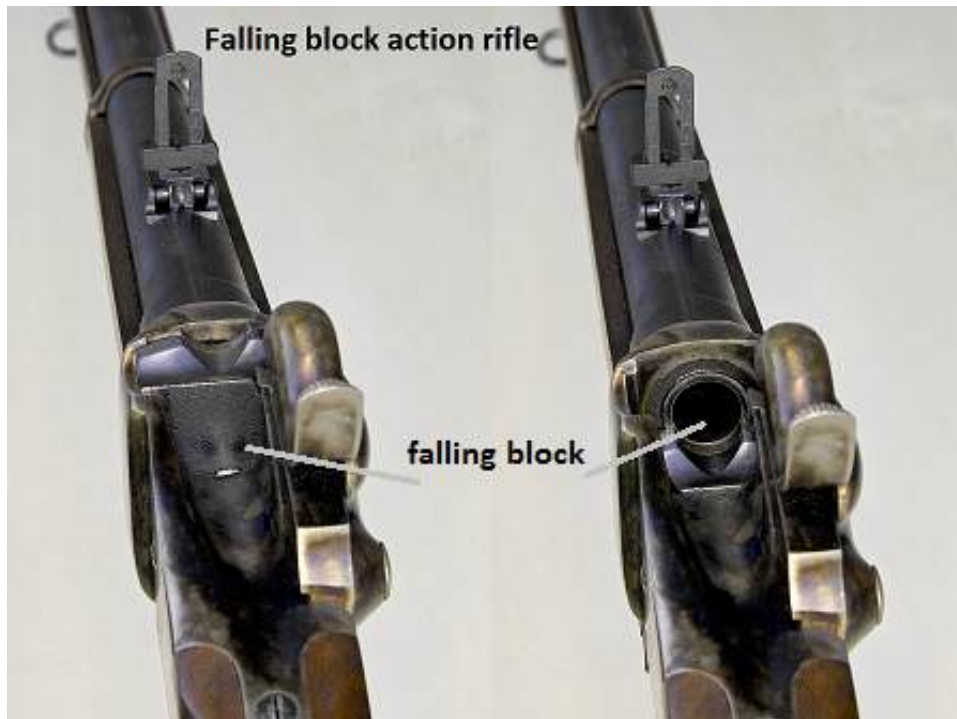
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Break action rifle

http://images4.wikia.nocookie.net/_cb20120211033932/aceofspadesfgf/images/3/3d/Double_barrel.jpg

**Shotguns**

Shotguns may be used for home defense, law enforcement, hunting, and shooting sports. The barrels in shotguns are not rifled, so the shot that has been fired will not spin upon travel. This makes this type of gun less accurate than a rifle. The ammunition used for this type of gun is a shotshell that may be filled with multiple projectiles. This helps to increase the probability of hitting a target. Some examples of shotguns are side-by-side, over and under, semi-automatics, and trap and skeet guns for shooting sports. The video that follows will give more information on these different types of shotguns.



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Over and under shotgun



Ammunition/Types of Bullets/Cartridge Cases



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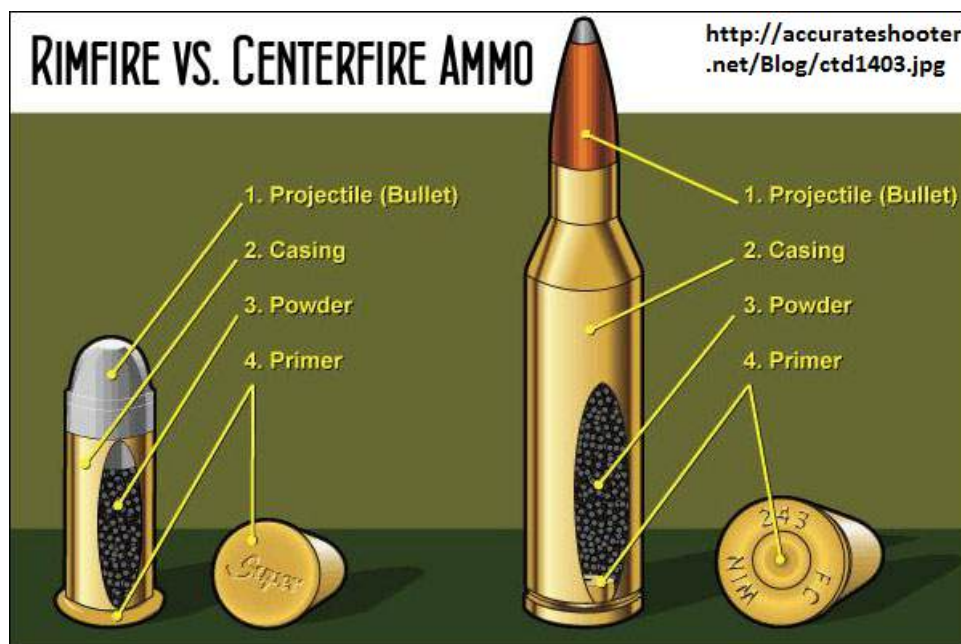
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Rimfire Ammunition

There are four basic parts to rimfire ammunition. The **primer** sparks the **gunpowder** found within the casing. The **casing** also holds the **projectile**, which is the bullet. When massive pressure is created within the casing, the bullet will come apart from the casing.

Most rimfire cartridges are made for .22 caliber handguns. Rimfire cartridges do not have a primer that is a separate element from the base of the cartridge. The primer is literally anywhere along the bottom of the rimfire. When a hammer hits the firing pin, the firing pin can make contact anywhere along to base to make the primer ignite the gunpowder on the inside of the casing to create the pressure needed to propel the bullet to be fired.



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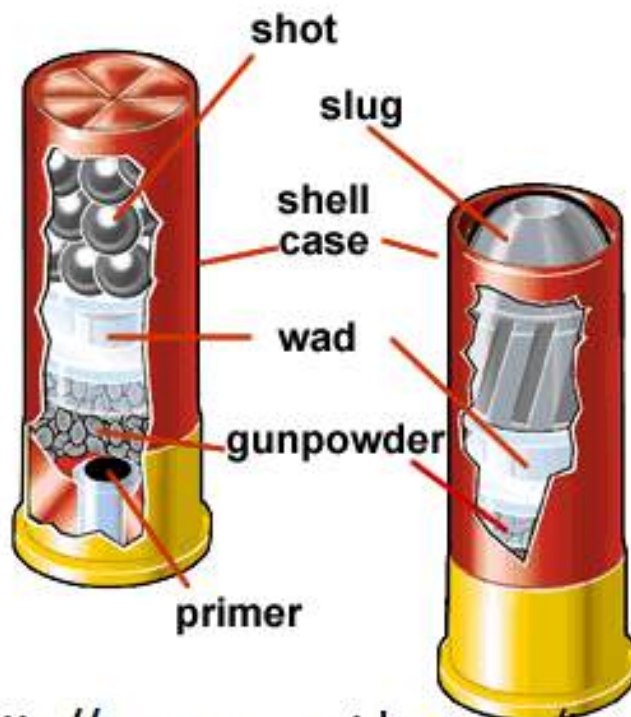
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Centerfire Ammunition

Centerfire ammunition is similar to rimfire ammunition, but differs in respect to the primer, which in this case, is a separate component. It is shock sensitive and once this part is hit by the firing pin, sparks create the combustion within the gunpowder. All other parts of this type of ammunition function the same as mentioned in the previous paragraphs. The majority of this type of ammunition is made for handguns and rifles.

The centerfire ammunition shown in the illustration above is specifically used for rifles. This is known as a **bottleneck cartridge**. The casing is specifically designed to hold more gunpowder, which in turn causes the projectile to travel at much higher speeds in order to travel further distances.

Shotgun Ammunition



<http://www.vanceoutdoors.com/images/shotshell.gif>

Shotshells come in various sizes and are called **gauges**. Shotshells have some basic anatomy as the previous mentioned types of ammunition. They have a primer, which once hit, causes the gunpowder to ignite. The **wad** is either made of paper or plastic, with plastic being more common. Wads are used to avoid the mixing of propellants and shots; they keep the gases behind the shot, and help cushion the shots so their shape does not warp. The **shell case** is similar to that of a cartridge case. Its task is to house all of the components. Last but not least, is the

projectile. The projectile in a shotshell may either be multiple single **shots** that can range from a diameter of 0.08 inches to .36 inches. It can also be a single projectile called a **slug**, which may vary in size depending on the caliber needed for the specific type of shotgun.



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Types of Projectiles (bullets)

There are various shapes and sizes found within bullets. The diameter of the bullet is known as the **caliber**. The image below shows live cartridges with just a few of the calibers available. Before they are shot, they maintain a specific shape, but will alter once they hit their target. When they hit the object intended, they will **fragment**, which either causes them to break apart or disfigure in shape. The table below shows various projectiles, gives a brief description, and informs what each bullet is used for.





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Bullet	Description	Uses
Full metal jackets  Flat http://media.midwayusa.com/product/images/880x660/Primary/386/386871.jpg Rounded http://media.midwayusa.com/product/images/880x660/Primary/413/413532.jpg	- Often called "ball ammunition" - The jacket made of copper, nickel, or a steel alloy covers the whole lead bullet - Can be rounded or flat as long as there is no hole in the middle - Bullet may penetrate multiple objects due to the solid nose of the bullet	Target shooting
 Jacketed soft point http://media.midwayusa.com/product/images/880x660/Primary/160/160006.jpg	- Bullet has a soft lead nose that allows for the bullet to spread out when it hits an object - Shell casing and bullet are imprinted with a <u>cannelure</u> to hold the bullet in position	Hunting
 http://media.midwayusa.com/product/images/880x660/Primary/591/591316.jpg Jacketed hollow point	- Tip is hollow to allow for a mushroom effect when it hits an object - Bullet will stay in the object it has hit as it expands and will not exit and hit a separate object	- Hunting - Self defense

http://www.m1911.org/images/lrn.gif  Lead round nose	- Made of lead - Tends to be a longer bullet - Rounded tip	Target shooting
 http://media.midwayusa.com/product/images/880x660/Primary/305/305180.jpg Semi-wadcutter	- Made of lead - Nose is tapered compared to the rest of the bullet body - Sharp shoulder leaves a clean hole in item shot	Target shooting

	• Made of lead • Cylinder-shaped • Sharp shoulder • Leaves clean hole in item shot	• Target shooting
	• Lead core jacketed with copper • Sharp tip, tapered base • Increases the stability in flight • Typically used in rifles	• Warfare • Hunting • Target shooting

Cartridge Cases

Cartridge cases are commonly made of brass. They serve to contain the gunpowder and the bullet. The primer is also attached to the bottom of the casing. This will be hit by the firing pin to initiate the cascade of events until the bullet is finally shot from the gun. A **headstamp** is found on the base of the casing. It will usually contain information such as the manufacturer, the caliber size, and may provide other valuable information.



Firearm Fabrication

All firearms are machined when they are fabricated which causes marks to be embedded within the firearm. These machined marks will be unique to that firearm, and that firearm only. This leaves marks which can be compared to unique fingerprints within the gun.



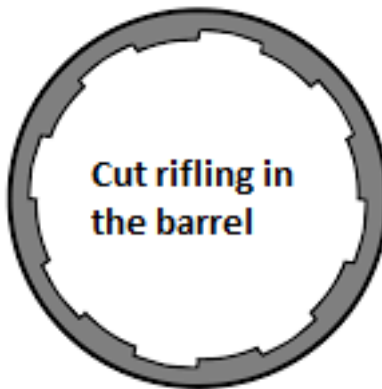
Barrel Fabrication

Grooves will be pressed or cut into the bore which produces rifling. This will ensure that the bullet spins out of the bore to increase constancy during its flight path. The rifling methods that will be discussed are broach cutting, button rifling, and hammer forging.

Broach Cutting

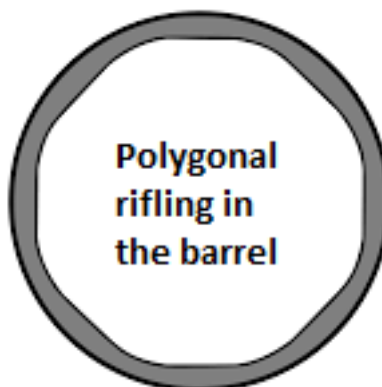
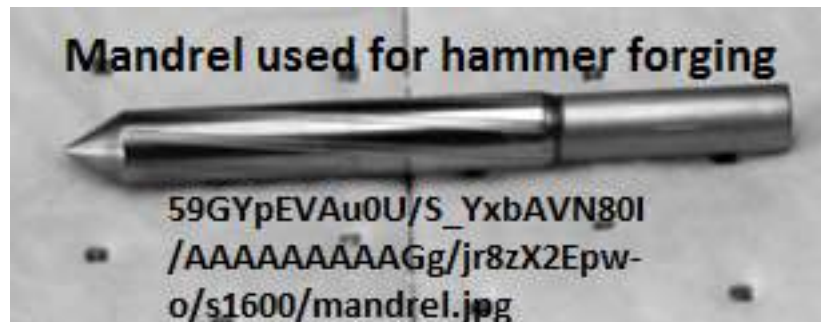


http://projects.nfstc.org/firearms/module04/images/fir_m04_t06_06_a.2.jpg



Broach cutting is achieved by applying pressure and spinning to the broach cutting tool as it passes down the metal piece which will eventually become the barrel of the gun. The edges of this tool are extremely sharp and will leave the grooves behind in the barrel. Once the broach has passed the entire length of the barrel one time, the barrel is removed. The broach is then removed from the machine and the process may be repeated to make more barrels. This process will leave behind **cut rifling** within the barrel, which appears as sharp pronounced areas between the lands and grooves (refer to <https://youtu.be/j0ka827PpcQ> for a video on broach cutting).

Hammer forged barrels





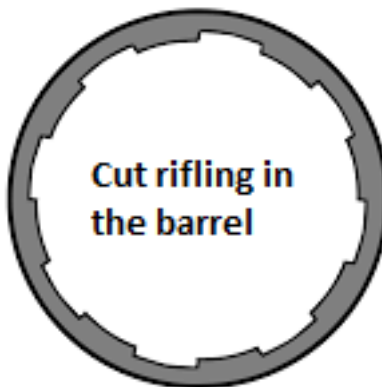
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A tool called a mandrel is placed inside of a barrel. The mandrel already has the grooves carved onto it. It is then placed into a machine in which hammers will pound the barrel from the outside, causing the inside to be imprinted by the mandrel. The machine will rotate the barrel to ensure that the pounding is done evenly throughout the barrel. This process will give rise to **polygonal rifling** inside of the barrel, which appear as smooth transitions within the grooves and lands.

Button rifling



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An extremely hard metal tool, called a plug will either be pressure pressed or pulled through a barrel by a machine to leave behind grooves within a barrel. This process will give rise to **cut rifling** within the barrel, which appears as sharp pronounced areas between the lands and grooves.

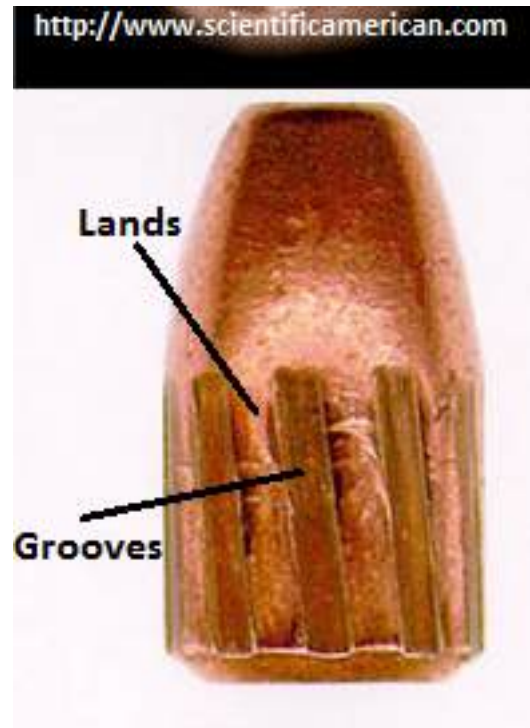
Comparing Bullets and Cartridge Cases

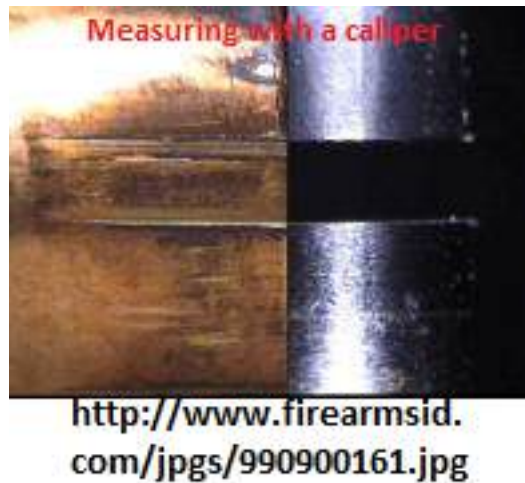
Bullets

Due to the manufacturing of guns, all barrels have four class characteristics that can be imparted onto the bullet that passes through it and can be measured. One will be the barrel diameter, called the **bore**, which will inform about the **caliber** (size/diameter) of ammunition that should be used within the firearm. Two is the number of lands and grooves that have been embedded within the barrel, and thus will be etched onto the bullet. Three is the direction of the twist, which is whether the lands and grooves are slightly angled to the left or right. And lastly, is the width of lands and grooves. All of these characteristics are measured in millimeters or hundredths of an inch. **Class characteristics** are similar within the barrels of a specific type of firearm. Such as all Smith and Wesson 37's will have 5 lands and grooves with a right twist.

The caliper shown below is a tool used to measure these characteristics. For example, the bullet below measures 10 mm. In order to convert it to inches, 10 is multiplied by 0.0394 in. This would yield 0.394 inches, which is a .40 caliber bullet. The raised parts on the bullet are counted around the whole exterior of the gun to give the land count. The same is done for the depressed portions which are the grooves. The two bullets shown side-by-side below demonstrate the slight twist to the left and right. Lastly, a caliper will be used to measure the lands and grooves. If one land is measured, the rest of the lands will be the same in size. That also holds true for the grooves. The caliper is to be placed directly on the edges of the groove to obtain a precise measurement, as well as for the land.

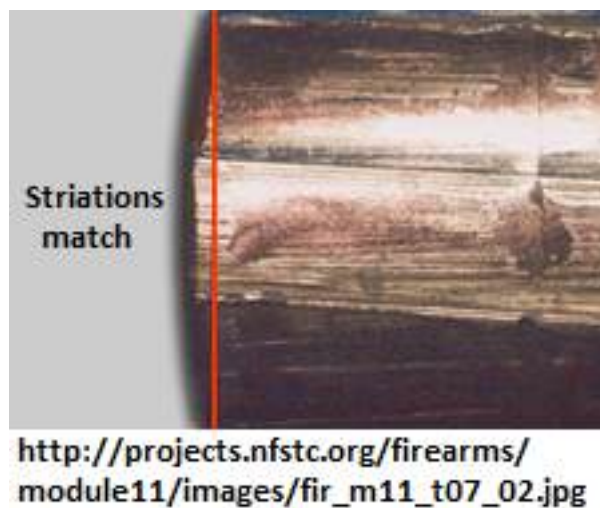


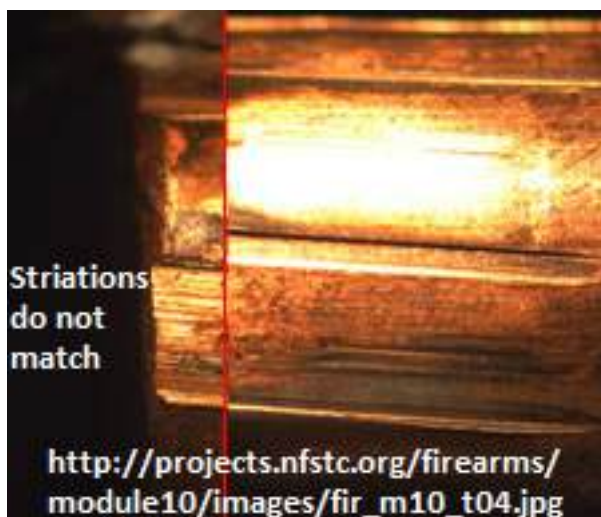




If the class characteristics of a fired bullet found at a crime scene and a suspect's gun match, the next step is to determine if the **individual characteristics** match. No successively rifled barrels will possess identical **striation** (fine lines made through the rifling process) markings, which makes each gun different from one another, even if it is the same exact manufacturer and model. This can be compared to fingerprints. No two people possess the same fingerprint; therefore, no two guns possess the same striations.

The gun will be used to fire a test bullet that will be compared to the crime scene bullet. A comparison microscope will be used to place the bullets next to one another, and also overlap them, to observe if the machined marks, called **striations** line up. If both the class and the individual characteristics harmonize, that proves that the crime scene bullet was fired from the suspect's gun. If the class and individual characteristics do not complement one another, the suspect's gun was not used to fire the bullet found at the crime scene, and can be excluded as a potential suspect.



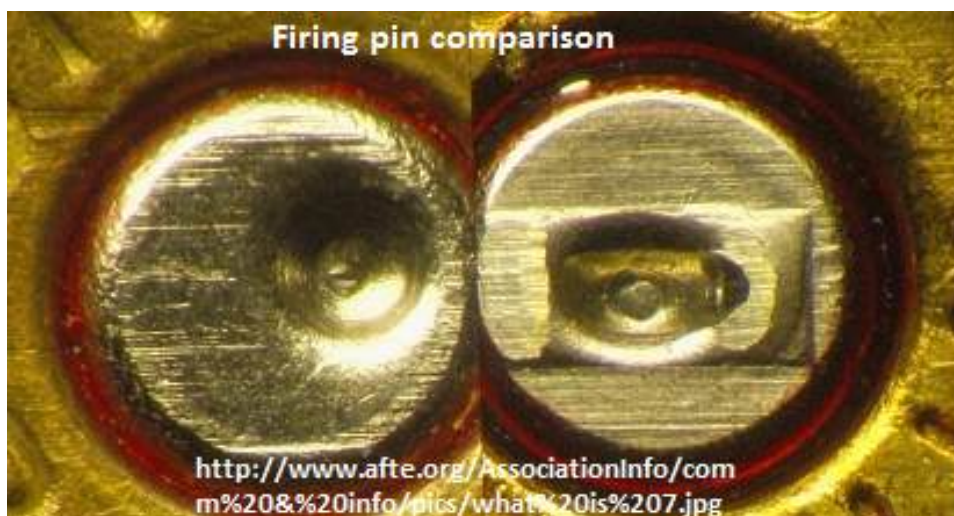


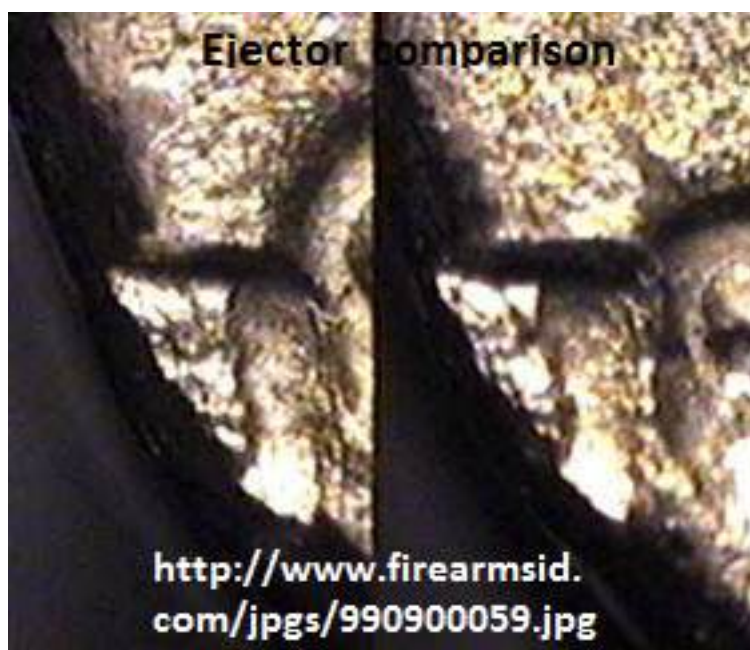
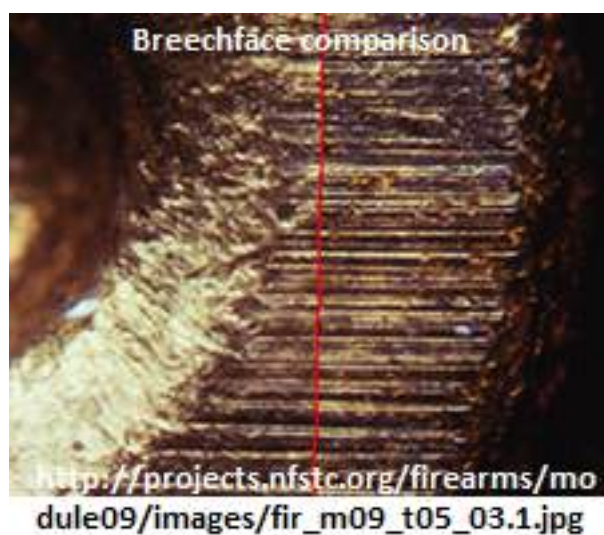
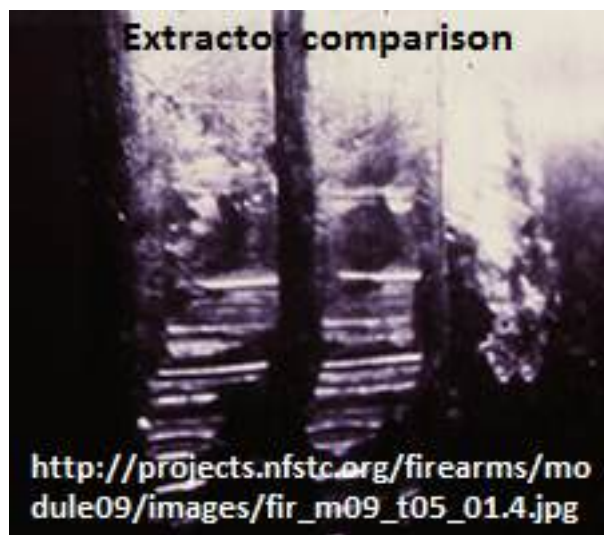
It is more of a challenge when a shotgun is used in a crime instead of a firearm with cut rifling. A shotgun has polygonal rifling, which leaves the barrel smooth. When a shotshell is fired, markings will not be etched from the barrel to the ammunition. Finding individual shots and the wad may help to reveal the gauge used along with the manufacturer.

There are instances in which a bullet is part of the evidence that has been found, but the gun has yet to be found. In this situation, the FBI has a record called the GRC, General Rifling Characteristics. All firearm class characteristics are documented in this file. For example, let's assume that a bullet found at a crime scene was found to be a .38 caliber and has 9 lands and grooves with a left twist. By looking this information up in the GRC, investigators will be able to determine the manufacturer of the firearm. There they will discover that it is made from Hi-Point (Beemiller), or High-Point Firearms, and will have a starting point when trying to locate the possible firearm used to commit the crime.

Cartridge Cases

When a gun is shot, the firing pin marks the primer on the live cartridge and leaves a mark. The extractor also grips the casing to ensure that it does not travel out of the barrel along with the bullet. The extractor leaves a mark on the rim of the casing. Once the bullet leaves the barrel, the pressure exerted forces the shell casing to hit the breechface, leaving striations on the back of the casing. Last but not least, is the ejector. The ejector will contact the casing and throw it out of the slide. This in turn, will leave a mark. A shell casing obtained from a crime scene and a test fired cartridge from a suspect's gun can be compared to see if they have similar markings. This will help to individualize a casing to a gun, just as in individualizing a bullet to a firearm.





Shotguns also have firing pins, extractors, breechfaces, and ejectors. These parts of the firearm will leave markings on the shell once it has been fired and will be very important when trying to tie a shell to the respective shotgun it was fired from. If a weapon has yet to be found, these markings may help to reveal the make and model of the weapon.

IBIS and NIBIN

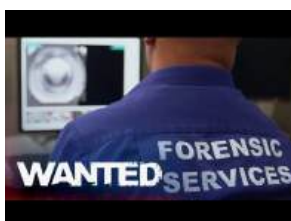
The **Integrated Ballistics Identification System**, or IBIS, is the software behind the ATF and FBI's NIBIN, or National Integrated Ballistics Information Network. It is responsible for storing two- or three-dimensional images of characteristics found on shot bullets and cartridge cases found at crime scenes and those fired in tests from guns taken from criminals. When an image of a new bullet or shell casing is entered into IBIS, the system will find possible matches from previous crime scene bullets and/or casings. An expert will then analyze the possibilities against the current evidence to determine if there is an absolute match. This technology has reduced the amount of time examiners spend on examining evidence dramatically.



MEDIA

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MEDIA

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NIBIN was founded in 1999. This program allows federal, state, and local agencies to share information making each entity more effective in solving cases. The program contains more than 800,000 images of bullets and/or casings from previous crimes. Every entry into this system is interconnected in real time. As soon as the entry is made, all agencies throughout the country are able to access the information.



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Gunshot and Primer Residue

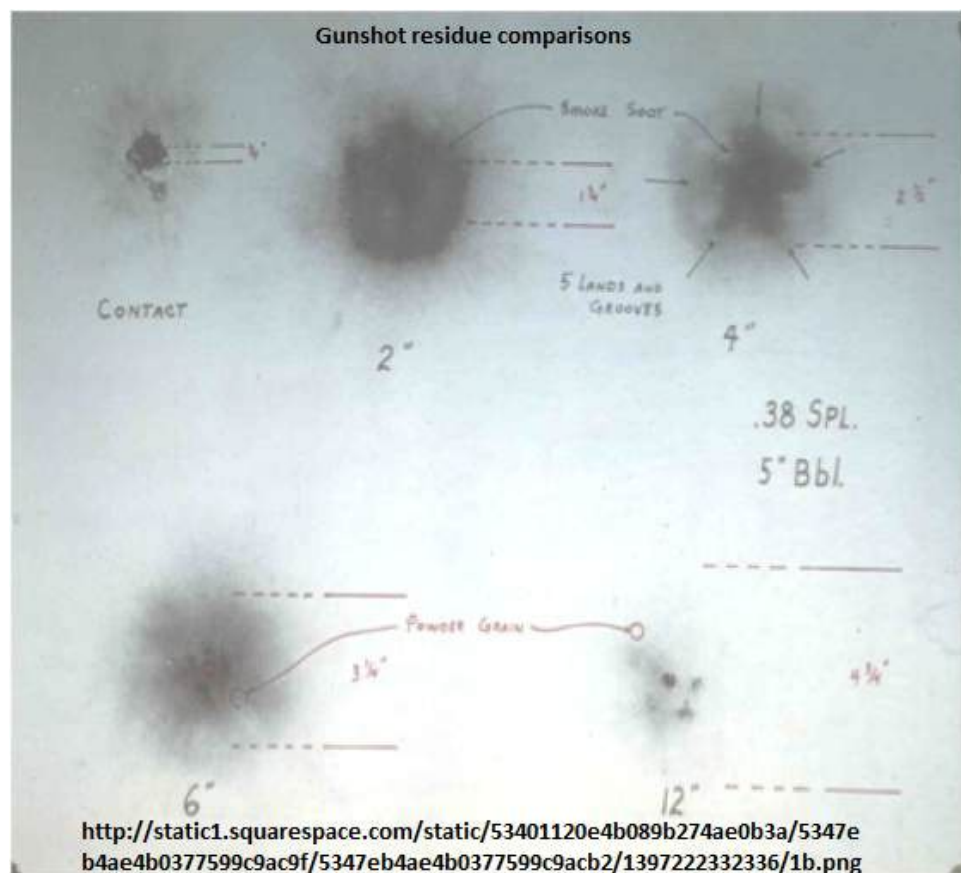
The propellants used in live cartridges are smokeless powders made of nitrocellulose and/or nitroglycerin. The distance from which the gun was fired towards the victim can be estimated by examining the **gunshot residue** left behind. This can reveal important information. For example, the residues may decipher whether a person committed suicide, or was actually murdered.

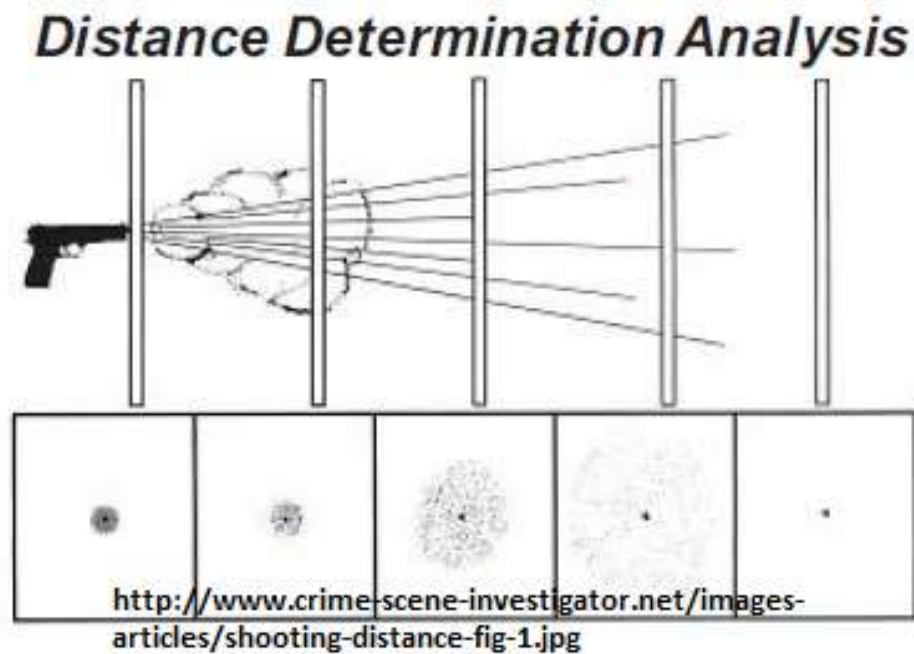
When a gun is fired, the bullet, unburned and partially burned gunpowder particles and smoke are shot in the direction of the victim. If the gun is fairly close, these items will appear on the victim. The gunpowder particles and residues surrounding the bullet cavity will provide information for estimating how close or far away the firearm was when it was shot.

The key lies in obtaining evidence from the victim, such as clothes they were wearing when shot, and making test samples from the actual gun used to commit the crime. The suspect gun is shot with the same type of live cartridges

used at the crime scene from different distances and compared to the evidence to approximate how far the gun was when it was shot. The table below describes characteristics found at varying distances.

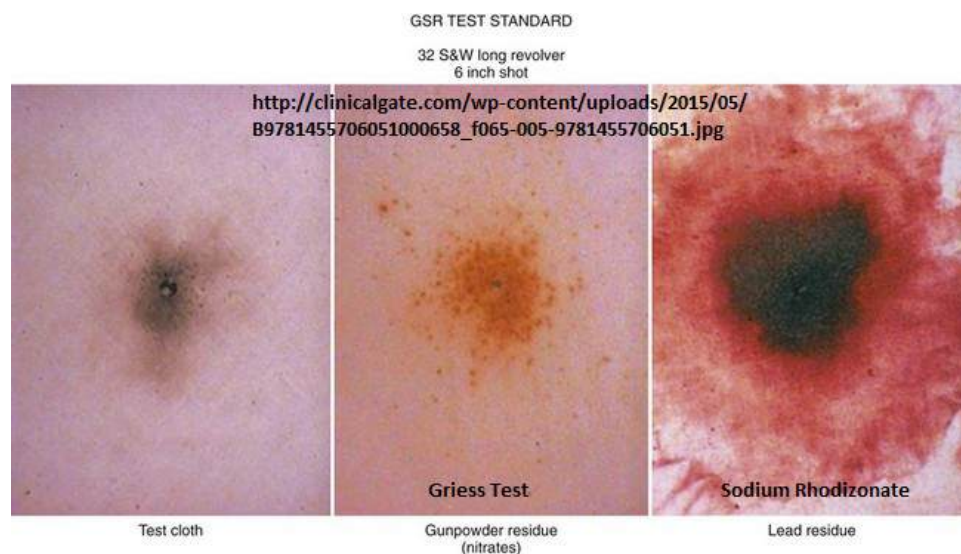
Approximate Distance	Characteristics
<1 inch away (also known as a contact shot)	- Star shaped tear around bullet hole - Hole is heavily surrounded by smokeless deposit of vaporous lead - Natural fibers may singe and synthetic fibers can melt
12-18 inches away	- Halo of smoke accumulated around bullet hole - Halo is made of vaporous lead
25-36 inches	- No soot present - Scattered specks of unburned and partially burned powder are present
3 feet or more	- No residue is present - Bullet wipe (dark ring) is present around the hole





The distance may also be estimated in shotguns. Here, the distribution of pellets are measured. If a shotgun was shot close to the victim and up to about five feet away, the pellets will enter the victim in a group that is a little bigger than the size of the barrel's bore. With added distance from the victim, the pellets will branch out further. As a rule of thumb, the pellets will broaden one inch per yard. So, if there is a five inch pattern, the shotgun was shot roughly five yards away from the victim.

When evidence is taken into a lab, everything will be visualized by a microscope. At times, gunpowder residue is visible, but in other situations, it is not visible, but does not mean that it is not present. Chemical tests may need to be performed such as the **Greiss Test**. This procedure tests for the presence of nitrites, which is a result of gunpowder burning. Desensitized photographic paper is treated with various chemicals to ensure that it will not be sensitive to light. The evidence is pressed against the photographic paper and ironed with acetic acid steam in the iron. If nitrites are present, the reaction will produce orange coloration on the paper.



Another test performed is the **Sodium Rhodizonate Test** to determine if lead residue is present. The evidence sample is sprayed with sodium rhodizonate followed by a buffer, which produces a pink color. This pink color is

a presumptive indication that lead is present. To confirm, a dilute HCl acid solution is sprayed. If lead is truly present, the pink color will change to blue, and lead is then confirmed.



MEDIA

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Primer residue and gunpowder can be found on the hand of a person that has recently fired a gun. Primers are made of lead styphnate (explosive), barium nitrate (oxidizer), and antimony sulfide (fuel) for the most part. Some of the recent compounds can be lead or barium free. Most .22 caliber rimfire ammunition possesses only barium, or it may not contain barium and/or antimony at all. When a person is suspected of firing a gun, the firing hand's thumb web and back of the hand will be swabbed so that it can be tested for primer residue. If a person has simply held a firearm, but not fired it, primer residues can be found on the palm. Even if a person has not fired, nor come into contact with a gun, but simply was close in proximity to the firearm as it was shot, can have primer residues found on them.

Testing for primer residues centers on detecting barium or antimony on a person's firing hand. Tape lifts may be performed on a victim's hand in order to recover any residues. Swabbing both hands with five percent nitric acid soaked cotton swab is another method used to recover primer residues. In any case, it is extremely important to collect these samples as close as possible to the time that the firearm was shot. It has been found that waiting four to five hours after a gun was shot, may totally remove any residues that may have been present previously. Waiting long periods of time will yield a low recovery rate of these residues. High levels of barium and antimony prove that a person has fired or handled a gun. It also may show that a person was simply close to a fired handgun.

SEM (scanning electron microscopy) analysis is a routine test used to determine if primer residue is present. The size and shape of these particles can be used to differentiate between any other contaminants. They are spherical in shape and the shape may be slightly distorted due to partially being melted. When SEM/energy dispersive X-ray spectrometry is used, an elemental finding of any lead, antimony, or barium is conclusive of primer residue. Also, the individual particles found in relation to the population of particles present must conclude that it came from primer residue and only primer residue as a possible source.



MEDIA

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MEDIA

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Tool Marks

A tool mark is an imprint left behind by a tool that comes in contact with a more malleable surface. These marks are frequently encountered in burglaries, and can be found in homicides as well. Studying the patterns left behind may reveal information such as the size and shape of the tool. It is extremely hard to pinpoint the exact tool that has created these depressions, and typically may only be tied back to a group of tools, and not a single tool. The only way that it can be individualized to one tool is if the tool had some previous damage to it that can't be attributed to any other tool.

There are specific marks made when a tool comes into contact with another surface. A **compression mark** shows an outline of a tool, such as a hammer hitting wood. A **sliding tool mark**, or **abrasion mark** is made when a tool slides along another surface, leaving striations behind. This can happen when a crowbar is used to try to pry a door open in a burglary. A **cutting tool mark** leaves striations behind when a surface is cut. This pattern can be imparted with tools such as scissors or chainsaws.

The comparison microscope is a valuable piece of instrumentation when trying to compare the test tool marks (in casting material) with the tool and compare them to the actual evidence imprint. If enough striations match between the two pieces, then the tool can be identified as being used at the crime scene.



http://www.allianceforensics.com/images/thumb_01.jpg

A knife's edge (on the right) is compared to rib cartilage cast from a victim (on the left).

This shows correlation between a suspect's knife and the victim's wound.



MEDIA

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Other imprints may be found at crime scenes that are not made by tools such as shoe prints, fabric impressions, and tire tread marks. Before anything is done with the imprints, a photograph with a scale must be taken. It should also show the location of the impression in regards to the rest of the crime scene. The next step is to transport the material that has the imprint to the lab. When it is found on an item such as glass or paper, it can be transferred to the lab without worry of destroying the impression.



If the item cannot be sent to the lab, such as impression in dirt, lifting the mark may be required. The impression will be lifted similar to lifting fingerprints. Electrostatic lifting devices may be another method that may be valuable when recovering scarcely visible prints made from dust. Mylar film is placed on the print and is pressed down with a roller. An electrode is placed on the mylar sheet and a metal plate. A charge develops attracting the dust to the mylar sheet, and the print is transferred.

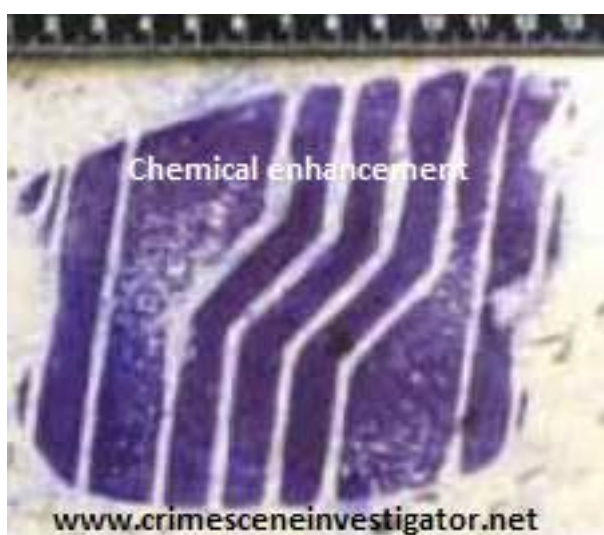


MEDIA

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Photographs and casting are preferred methods to preserve shoe marks and tire tread marks. Once the cast is done, it needs to be dried fully before it makes its way to the lab. The cast can then be compared to the suspect's shoe when it is retrieved. If shoeprints are found containing blood, the prints may be better visualized by using a chemical enhancer. This will help an almost nonexistent print become highly visible after treatment. Leuco Crystal Violet is commonly used to enhance these prints. When LCV and hydrogen peroxide come into contact with the hemoglobin in blood, the solution produces a purple color.



**MEDIA**

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An adequate number of comparison points will help to aid that the questioned and test impressions came from the same source. New computer software and websites may be able to assist in making comparisons with shoeprint and tire impressions. Also, bite mark impressions on skin and food items are important evidence in homicide and rape cases that can be backed by an odontologist.

Evidence Collection

- Every item must be documented, tagged, and entered into a chain of custody.
- Notes, sketches, and photographs must be taken of each item sent to the lab.
- Firearms must be labeled with the make, model, serial number, and investigator's initials.
- If a firearm is found in water, it must be transported in a container that holds the same water it was found in to prevent any oxidation of the metal. Once removed, it may be sprayed with copious amounts of WD-40 to further prevent rusting.
- If a gun is removed from saltwater, it has to be rinsed, heavily oiled, and sent to the lab without delay.
- When a firearm is picked up, it must be held by the edge of the trigger or the patterned part of the grip to not distort any latent fingerprints.
- Nothing should be allowed to come into contact with the barrel or the breechface of a firearm.
- Do not insert any objects on the inside of the gun.
- If a weapon is loaded, it must be unloaded for safety purposes. If this is done, notes must be taken on how the gun was found, and how much ammunition was found inside. If there is a magazine, it must be removed and dusted for prints.
- As long as the weapon is unloaded, it may be submitted to the lab.
- Empty casing may be left in the chambers of a revolver, and may be removed once they reach the lab.
- If a gun is found corroded, it is appropriate to send it to the lab loaded. The lab must be notified beforehand and should be delivered in person, and not by mail.
- Never dry fire a weapon that is submitted as evidence.
- If any item recovered contains body fluids, it has to be labeled as a biohazard.
- If a revolver is recovered, the chamber location that lines up with the barrel must be documented. Each chamber is documented by number, and as cartridges are removed, those are numbered according to the chamber numbers. Each cartridge must be wrapped in cotton or tissue and packaged separately in boxes or envelopes.
- If a bullet is found bound in a surface, the surface is to be chipped away until the bullet dislodges on its own to prevent any scratches directly on the bullet.
- The container a bullet or casing is placed in must be marked with the investigator's initials and other relevant information.
- If wads are found, they must be packaged and sent to the lab.
- Whether the evidence is a bullet, shell casing, wad, etc., the location it was recovered from must be recorded.
- If many bullets or casings are found in the same area, they may be packaged in the same container as long as they are individually wrapped in tissue to prevent any contact within them.
- To prevent any damage to a bullet, it is important to wrap it in tissue before it is placed in an envelope or pillbox and sent off to the lab.
- If anything is found attached to a bullet, it is important to leave such materials on the bullet, and not attempt to remove them.
- If clothing is found with potential gunshot residue, send the entire item. Do not cut any samples out of the cloth.

- If testing for gunshot residue on clothing, the firearm must be submitted as well for distance determination.
- If clothing is wet, allow it to dry without the help of the sun. Fold the item to help preserve the bullet hole and gunshot residue. Package each item in a separate paper bag. Do not let any separate clothing items to come in contact with one another.
- Surfaces that need to be tested on tools should be protected to prevent any damage.
- Tools are only tested when they are linked to a suspect by fingerprints or ownership.
- If the entire tool may be submitted, send it in its entirety to the lab. If not, it can be photographed with a scale and preserved in a casting material.
- Never try to fit a tool obtained from a suspect into the actual mark that was made. This may modify the mark, rendering it useless.
- Tools and marks are to be packaged in separate containers. It may be wise to wrap the items before they are packaged to protect them during shipment to the laboratory.
- If anything is found adhering to the tool, such as fiber, take special care in packaging the evidence to ensure that it stays intact.



MEDIA

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Chapter Summary

- Rifling is known to help with the rotation of the ammunition as it travels through the barrel of the firearm.
- In a revolver, cartridges are loaded into the cylinder, and the hammer is cocked.
- The pulling of the trigger will put the hammer into a forward motion, hitting the firing pin, which strikes the primer on the back of the cartridge, which then ignites the gunpowder, which causes a pressure buildup and fires the bullet from the barrel of the gun. The shell casings remain in the cylinder's chambers.
- The breechface is where the back of the cartridge sits before it is fired and gets imprinted onto the back of the cartridge, which serves as a comparison point to determine whether a cartridge was actually shot from a specific firearm.
- In a semiautomatic handgun, ammunition is loaded into the chamber and inserted into the grip, used to hold the gun.
- The slide is pulled backwards to cock the hammer and the trigger is pulled, which forces the hammer to come in contact with the firing pin, thus hitting the primer as mentioned above.
- The extractor is responsible for withdrawing the shell casing from the barrel so that it does not propel through the barrel with the bullet that has been set in motion.
- The ejector's duty is to expel the fired cartridge case from the momentary opening in the slide. As mentioned above, the extractor keeps the shell casing from traveling through the barrel.
- Revolvers require cartridges to be loaded into the cylinder's chambers. Semiautomatic guns require cartridges to be loaded into magazines, which must then be inserted into the grip of the gun.
- Rifles are so named because the bore is rifled, which means that there are spiral grooves present that help make the shot fired more accurate. There are different types of rifles that may be used for warfare, hunting game, and shooting sports.
- The barrels in shotguns are not rifled, so the shot that has been fired will not spin upon travel, making it less accurate. Shotguns may be used for home defense, law enforcement, hunting, and shooting sports.
- Rimfire cartridges do not have a primer that is a separate element from the base of the cartridge. The primer is literally anywhere along the bottom of the rimfire. When a hammer hits the firing pin, the firing pin can

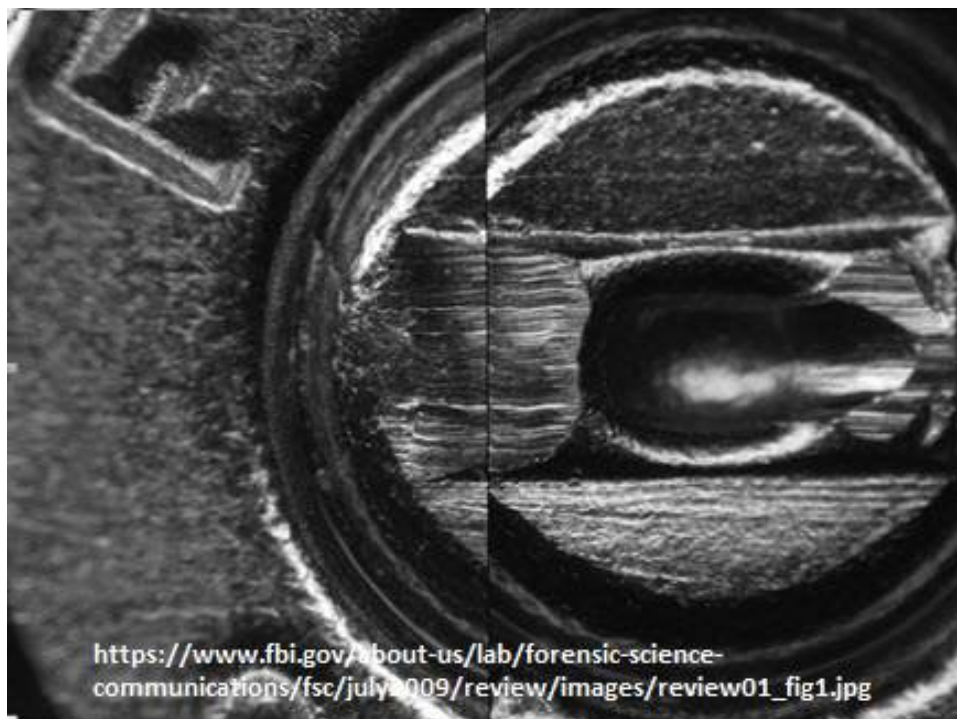
make contact anywhere along to base to make the primer ignite the gunpowder on the inside of the casing to create the pressure needed to propel the bullet to be fired.

- Centerfire ammunition is similar to rimfire ammunition, but differs in respect to the primer, , which in this case, is a separate component. It is shock sensitive and once this part is hit by the firing pin, sparks create the combustion within the gunpowder. All other parts of this type of ammunition function the same as mentioned above.
- Shotshells come in various sizes called gauges. They have components such as the primer, gunpowder, wad, shot or slug, and shell case.
- The diameter of a bullet is known as its caliber.
- Once a bullet hits an object, it will no longer maintain its shape, and will fragment.
- There are various types of bullets that differ from one another such as full metal jackets, jacketed soft points, jacketed hollow points, lead round noses, semi-wadcutters, wadcutters, and boat tails.
- Cartridge cases hold the gunpowder and the bullet.
- Rifling methods such as broach cutting, hammer forging, and button rifling are used within the barrels of guns.
- Bullets' class characteristics such as caliber, the number of lands and grooves, the direction of twist, and the width of lands and grooves can be measured. These characteristics are similar within barrels of a specific type of firearm, such as Smith and Wesson 37's.
- No successively rifled barrels will possess identical striation (fine lines made through the rifling process) markings, which makes each gun different from one another, even if it is the same exact manufacturer and model. This is known as an individual characteristic and makes each firearm different from one another.
- The FBI has a record called the GRC, General Rifling Characteristics. All firearm class characteristics are documented in this file.
- When a gun is shot, the firing pin, extractor, breechface, and ejector will contact with and leave marks on the casing. A shell casing obtained from a crime scene and a test fired cartridge from a suspect's gun can be compared to see if they have similar markings. This will help to individualize a casing to a gun, just as in individualizing a bullet to a firearm.
- IBIS is responsible for storing two- or three-dimensional images of characteristics found on shot bullets and cartridge cases found at crime scenes and those fired in tests from guns taken from criminals.
- NIBIN allows federal, state, and local agencies to share information making each entity more effective in solving cases.
- The distance from which the gun was fired towards the victim can be estimated by examining the gunshot residue left behind.
- In shotguns, the rule of thumb is that the pellets will broaden one inch per yard shot away from the victim.
- The Greiss Test analyzes for the presence of nitrites, which is a result of gunpowder burning.
- Another test performed is the Sodium Rhodizonate Test to determine if lead residue is present.
- Primer residues are made of lead styphnate (explosive), barium nitrate (oxidizer), and antimony sulfide (fuel) and are tested for on a person who has recently shot a gun.
- SEM (scanning electron microscopy) analysis is a routine test used to determine if primer residue is present.
- A tool mark is an imprint left behind by a tool that comes in contact with a more malleable surface. Studying the patterns left behind may reveal information such as the size and shape of the tool.
- The comparison microscope is a valuable piece of instrumentation when trying to compare the test tool marks (in casting material) with the tool and compare them to the actual evidence imprint.
- Other imprints may be found at crime scenes that are not made by tools such as shoe prints, fabric impressions, and tire tread marks.
- Photographs, lifting techniques, electrostatic lifting devices and casting may need to be performed to preserve these tool marks and/or impressions.
- An adequate number of comparison points will help to aid that the questioned and test impressions came from the same source.
- Collecting and packaging evidence is of utmost importance when dealing with firearms and tool marks.

Review Questions

Short Answer

1. How are the barrels of handguns and shotguns different? How does it make the job of an examiner more difficult when trying to assess if two shotshells were shot from the same barrel?
2. GSR has been found on a victim's head wound. Examiners found a gun in the victim's hand, and it appears to be a suicide. No residue is present near the bullet wound and there is a bullet wipe present around the hole. Did the victim commit suicide?
3. Impressions have been found on multiple surfaces. A visible and clear shoe print has been found on tile and another has been found in dirt. How would both impressions be collected for further analysis?
4. Compare and contrast rifles and shotguns
5. What are the phases that occur in order to expel a bullet from the barrel of a gun?



6. The picture above is a comparison of two cartridge cases. One has been found at a crime scene, and the other is a test fired case from the suspect's gun. How would you relay the results to an investigator working on the case?
7. A suspect has been taken into the police station for questioning involving a shooting that occurred one hour previously. There, a sample is collected for primer residue to determine if he was the shooter. Later, a .22 caliber cartridge case was recovered at the crime scene. How does this pose a problem when testing for primer residue? Is it likely that they will find primer residue on his shooting hand?

True or False

8. True or False: The lands in the barrel impart the lands on the bullet.
9. True or False: If fiber is found attached to a tool, the fiber must be removed with forceps. The fiber is then packaged separately from the tool to prevent any loss of evidence.
10. True or False: The individuality of a tool mark may be determined by the striations left behind on the tool that were made by the manufacturer.
11. True or False: Hammer forged barrels present with cut rifling in their barrels.
12. True or False: NIBIN is the software used by IBIS. IBIS allows federal, state, and local agencies to share information making each entity more effective in solving cases.

13. True or False: If a bullet is found bound in a surface, the bullet must be pulled out of the surface with pliers to not distort the hole that was made. The hole must remain intact for further analysis.

Multiple Choice

14. Which part of this cartridge (shown below) is the reason it is called centerfire ammunition?



1. Bullet
 2. Propellant
 3. Cartridge case
 4. Primer
15. This tool was passed through the barrel of a gun. When the gun has finished going through the manufacturing process and has been shot, which type of rifling would be imparted on the bullet that passes through the barrel?



1. Polygonal rifling
2. Cut rifling

16. A bullet has been recovered from a crime scene and has been examined for its characteristics. Determine ALL firearm possibilities.

Diameter: .450 inches

Lands: 6

Groove width: .069-.079

Grain weight: 230 grains

Rifling type: cut

Twist: left

Land width: .155-.175

Bullet type: FMJ

Caliber	Cartridge	Manufacturer	Model	Rifling Type	L/G Twist	Land Min	Land Max	Groove Min	Groove Max
45	45 AUTO	COLT	1905	C	06-L	0.036	0.043	0.186	0.192
45	45 AUTO	DGFM (FMAP)	MODEL 1927	C	06-L	0.05	0.055	0.16	0.165
45	45 AUTO	COLT	MKIV	C	06-L	0.058	0.078	0.155	0.17
45	45 AUTO	COLT	1913	C	06-L	0.07	0.072	0.16	0.165
45	45 AUTO	COLT	DOUBLE EAGLE 90	C	06-L	0.07	0.072	0.158	0.16
45	45 AUTO	COLT	COLT COMMANDER	C	06-L	0.07	0.072	0.16	0.162
45	45 AUTO	AUTO ORDNANCE	1911A1	C	06-L	0.07	0.073	0.154	0.16
45	45 AUTO	COLT	GOLD CUP	C	06-L	0.07	0.074	0.16	0.165
45	45 AUTO	NORINCO	1911A1	C	06-L	0.07	0.082	0.146	0.155
45	45 AUTO	STAR	?	C	06-L	0.071	0.071	0.158	0.158
45	45 AUTO	COLT	1911A	C	06-L	0.071	0.072	0.159	0.162
45	45 AUTO	BROWNING	BDA	C	06-L	0.072	0.078	0.154	0.156
45	45 AUTO	FOX	FOX CARBINE	C	06-L	0.095	0.098	0.13	0.135
45	45 AUTO	SPRINGFIELD ARMORY	DEFENDER	C	06-L	0.095	0.098	0.13	0.135
45	45 AUTO	FN/BROWNING (SIG)	SIG-SAUER (BDA)	C	06-L	0.098	0.101	0.125	0.135
45	45 AUTO	FN/BROWNING	BDA45	C	06-L	0.1	0.105	0.125	0.13
45	45 AUTO	SIGARMS	P220	C	06-L	0.101	0.105	0.125	0.132
45	45 AUTO	GABILONDO	?	C	06-L	0.103	0.108	0.122	0.13
45	45 AUTO	MILITARY ARMS CORP	M10A1	C	06-L	0.108	0.112	0.108	0.112

1. DGFM, Colt, Auto Ordnance
2. Colt, Norinco, Star, Browning
3. Auto Ordnance, Norinco, Colt, Star, DGFM
4. Browning, Star, Norinco, Auto Ordnance, Colt

17. What is the difference between a bullet's class characteristics and individual characteristics?

1. Class characteristics are unique marks caused by the manufacturing process. These marks cause striations on the bullet which can be used for comparison purposes. Individual characteristics are measurable features of a specimen which indicate a restricted group source. They result from design factors, and are therefore determined prior to manufacture.
2. Class characteristics are measurable features of a specimen which indicate a restricted group source. They result from design factors, and are therefore determined prior to manufacture. Individual characteristics are unique marks caused by the manufacturing process. These marks cause striations on the bullet which can be used for comparison purposes.

18. Why is having a cannellure on live ammunition an added advantage?

1. It allows for more gunpowder to be added.

2. It makes the bullet expand when it impacts an object.
3. It helps to keep the bullet in place.
4. It increases the surface area of the bullet.

19. What is the difference between a FMJ and a hollow point?

1. The FMJ expands upon impact, whereas a hollow point may typically penetrate multiple objects.
2. FMJ's allow for increased stability and hollow points are used to shoot at shorter distances.
3. The hollow point usually has a waxy lubricant to aid in keeping the barrel clean. The FMJ is made out of lead alloy and has a rounded nose.
4. The ball ammo is used primarily for target shooting, whereas the hollow point is used for self defense.



20. What is the function of the part emphasized in the rectangle above?

1. It grabs the cartridge case and pulls it from the barrel after firing.
2. It kicks the fired cartridge case from the firearm when the slide is traveling rearward.
3. It pulls the cartridge to the rear under spring tension.
4. It fires the cartridge.

CONCEPT

13

Unit 11 DNA Fingerprinting

Unit 11 DNA Fingerprinting

TEKS

- Collect and organize qualitative and quantitative data and make measurements with accuracy and precision using tools such as calculators, spreadsheet software, data-collecting probes, computers, standard laboratory glassware, microscopes, various prepared slides, stereoscopes, metric rulers, electronic balances, gel electrophoresis apparatuses, micropipettors, hand lenses, Celsius thermometers, hot plates, lab notebooks or journals, timing devices, cameras, Petri dishes, lab incubators, meter sticks, and models, diagrams, or samples of biological specimens or structures. [2F]
- Analyze, evaluate, make inferences, and predict trends from data. [2G]
- Communicate valid conclusions supported by the data through methods such as lab reports, labeled drawings, graphic organizers, journals, summaries, oral reports, and technology-based reports. [2H]
- In all fields of science, analyze, evaluate, and critique scientific explanations by using empirical evidence, logical reasoning, and experimental and observational testing, including examining all sides of scientific evidence of those scientific explanations, so as to encourage critical thinking by the student. [3A]
- Evaluate the impact of scientific research on society and the environment. [3D]
- Evaluate models according to their limitations in representing biological objects or events. [3E]
- Research and describe the history of science and contributions of scientists. [3F]
- Explain the functions of national databases available to forensic scientists. [5I]
- Diagram the deoxyribonucleic acid molecule, including nitrogen bases, sugars, and phosphate groups. [12A]
- Explain base pairing of adenine, thymine, cytosine, and guanine as they relate to deoxyribonucleic acid fingerprinting. [12B]
- Extract deoxyribonucleic acid from food such as peas and strawberries. [12C]
- Explain the polymerase chain reaction laboratory procedure for forensic deoxyribonucleic acid typing. [12D]
- Collect and package deoxyribonucleic acid from a simulated crime scene. [12E]
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Introduction

Like fingerprints, DNA is unique to each individual, therefore DNA is one of the most valuable tools to verify identities, include or exclude suspects, and ultimately solve crimes. Forensic scientists can use DNA found in Skin, sweat, blood, mucus, saliva, tissue, semen, urine, hair, ear wax, vaginal, and rectal cells found at a crime scene or on a victim to identify a matching DNA of an individual, who could be the suspect of the crime. This process can be either called DNA profiling or genetic fingerprinting.

Objectives

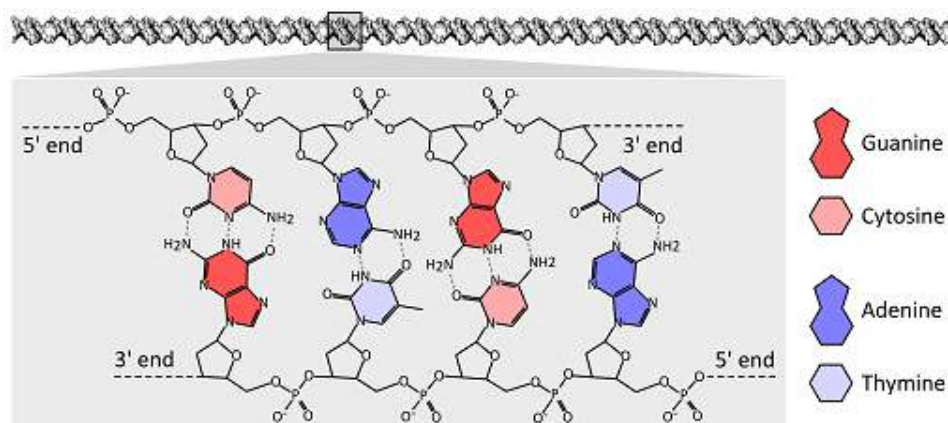
The student will be able to:

1. Diagram the DNA molecule.
2. Explain the polymerase chain reaction laboratory procedure.
3. Demonstrate how to package, collect, and analyze DNA from a simulated crime scene.



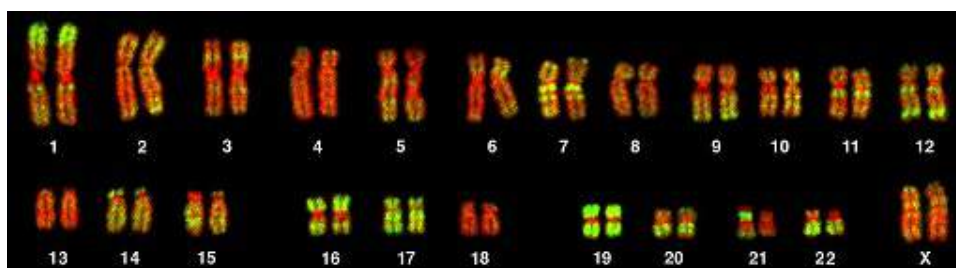
What is DNA?

Deoxyribonucleic acid also known as DNA, contains the biological instructions that makes every individual unique and therefore identifiable.



DNA is made up of nucleotides that contain a phosphate group attached to a sugar group and one of four types of nitrogen bases (adenine (A), thymine (T), guanine (G) and cytosine (C)). To form a strand of DNA, nucleotides are linked into chains, with the phosphate and sugar groups making the back bone of the Double helix.

Individuals inherit half of their nuclear DNA from the father and the other half from the mother, it is important to note that DNA can also be found in the mitochondria which is passed maternally. This is because the female egg keeps their mitochondria during fertilization, unlike the male sperm cells. After this process the offspring will inherit about 3 billion bases making up 20,000 genes all within 23 pairs of chromosomes.

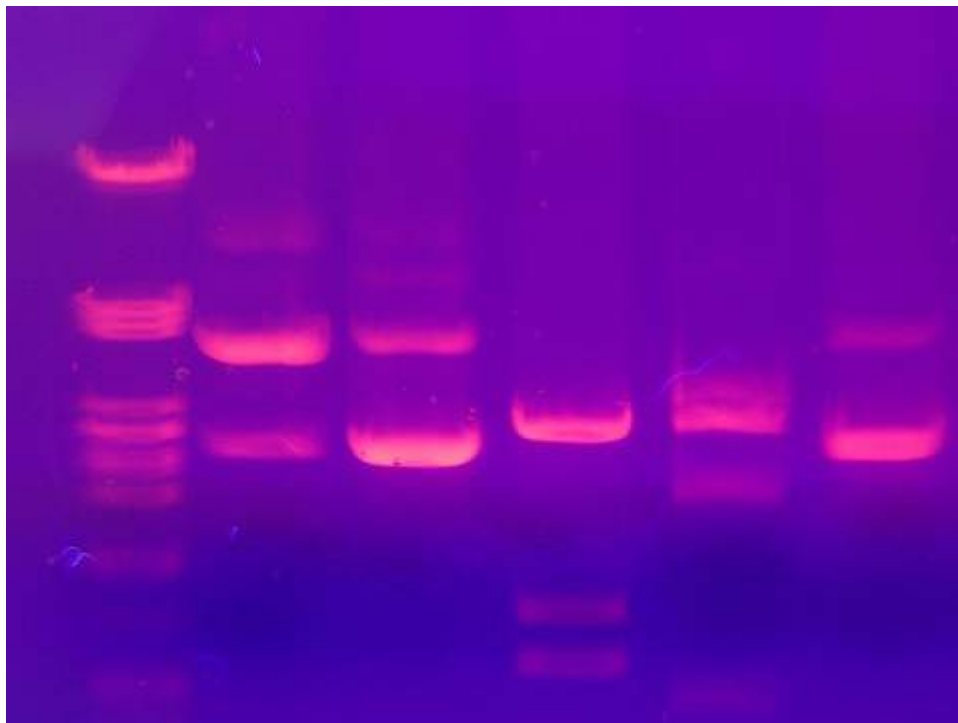


DNA History

The Swiss biochemist Frederick Miescher first observed DNA in the late 1800s, but did not comprehend its importance. It took nearly a century for researchers to acknowledge the DNA molecule as an important structure vital for life's existence.

For many years, scientists debated which molecule carried life's biological instructions. Most thought that DNA was too simple a molecule to play such a critical role. Instead, they argued that proteins were more likely to carry out this function because of their greater complexity and wider variety of forms. The notion that genes are found on chromosomes began with the research produced by T.H. Morgan in 1908. His work led to the debate of whether protein or DNA found in chromosomes are responsible for the genes that ultimately give rise to heredity. It was in 1928 that Frederick Griffith discovered that there was a "Transforming Factor" that was passed from dead active bacteria to live inactive bacteria and transformed the inactive bacteria to active while working with the *Streptococcus pneumonia* bacteria in mice. He concluded that DNA is the "Transforming Factor". It wasn't until 1944 that Avery, McCarty & MacLeod finally put the question of whether it was the protein or the DNA found in chromosomes that is responsible for the genes to rest. They purified both DNA & proteins from the *Streptococcus pneumonia* bacteria. Their plan was to find out which would transform the inactive bacteria into an active form? They first injected the purified protein into the inactive bacteria with no effect. They then injected the purified DNA into the inactive bacteria, which in turn transformed the harmless bacteria into virulent active form. This confirmed the belief that it was the DNA that made up the genes found in our chromosomes. The importance of DNA became clear within the 1953-1965 with the contributions made available by the work of James Watson, Francis Crick, Maurice Wilkins, and Rosalind Franklin. By studying X-ray diffraction patterns and building models, the scientists figured out the double helix structure of DNA.

This leads into the discussion of DNA and forensics in 1984, with the discovery that enabled for the identification of individuals from their own DNA by the use of Restriction Fragment Length Polymorphism (RFLP), dubbed DNA Fingerprinting by Sir Alec Jeffreys. This method was put to the test in 1986, when DNA was used for the first time to identify Colin Pitchfork as the murderer of two young girls in the English Midlands.



DNA Collection Comparison

It is the responsibility of the forensic investigation team to gather samples from the crime scene and from suspects

and then analyze it for a set of specific DNA regions or markers. A match of one marker is not usually unique, but if a sample matches four or five markers, there is a very good chance it is a match.

DNA Collection

DNA is collected at crime scenes in a variety of ways using tools such as:

Smear slides, scalpels, tweezers, scissors, sterile cloth squares, UV light, luminol and/or blood collection kits (for sample collection of suspects or living victims)

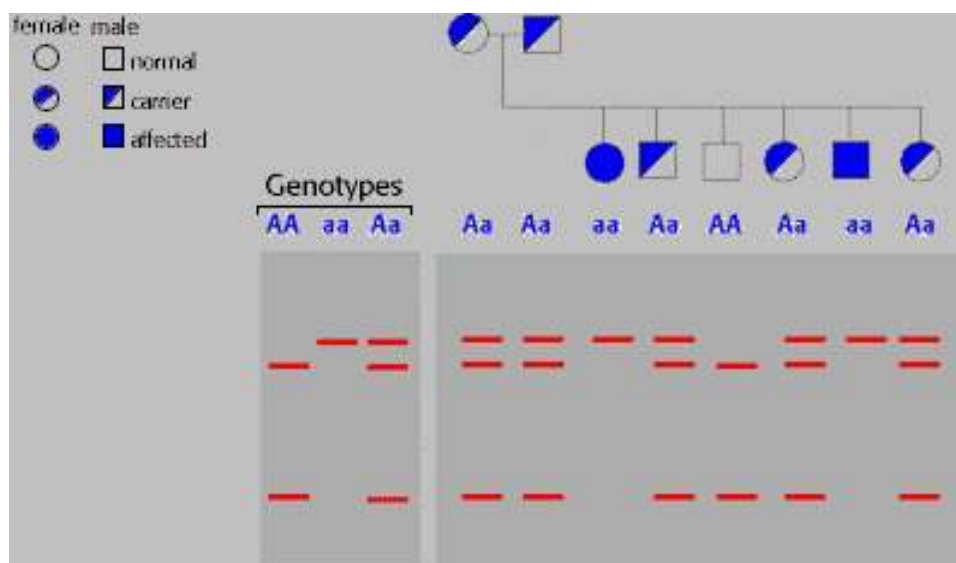
DNA samples can be collected from saliva, blood, hair strands, skin, finger or toe nails, and/or a tooth with root material.

How is blood collected

When blood is collected from clothing, the forensic technician will submit all the clothing that is tainted with blood or if needed they will send a small sample to the lab while the crime scene is still being investigated. The technician will also use a sterile cloth square and a small amount of distilled water to absorb blood from the victim or suspect for analysis. When blood is found on furniture, the whole piece will be sent to the lab if possible. If not, then samples will be taken from the furniture. When blood is found on a wall, tub or some other object too big or difficult to move to the lab, the technician will scrape the blood sample into a sterile container for further analysis.

Analyzing DNA

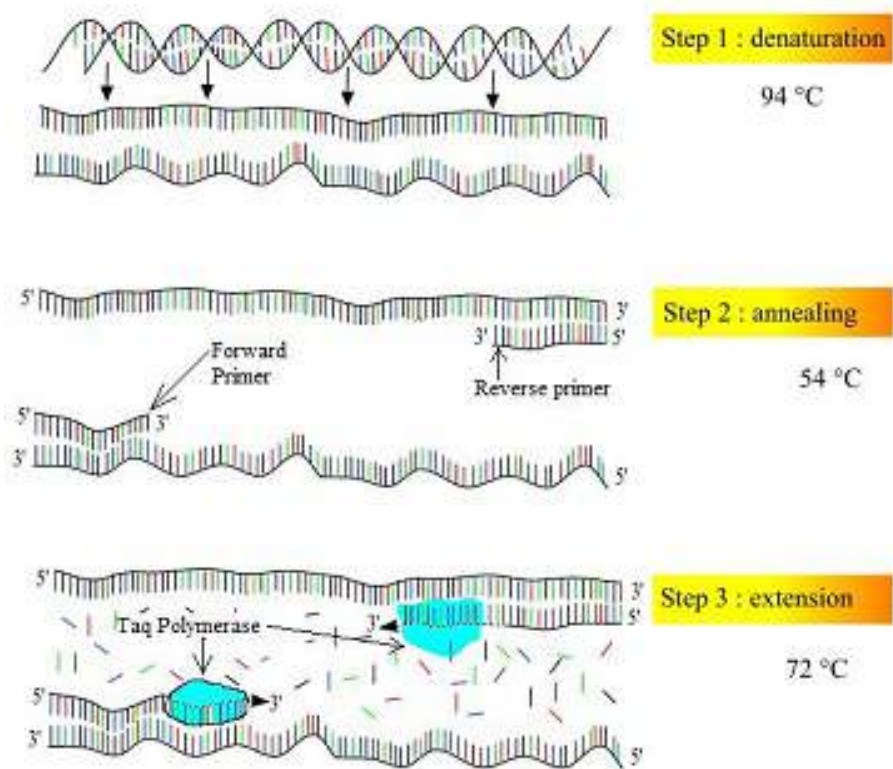
When preparing the analysis of DNA for identification of an individual, the DNA is converted into a series of bands called DNA typing. It is important to note that only a small percentage of DNA differs from one person to the next, therefore only segments of one's DNA are used to create a DNA profile. There are many different methods that can be used, it all depends on the amount of the sample and how it was found; How old is the sample and how degraded is it. Restriction Fragment Length Polymorphism (RFLP), Polymerase Chain Reaction (PCR), Short Tandem Repeats (STR), Mitochondrial DNA Analysis (MTDNA), and Electrophoresis are all methods used to analyzing DNA.



- **Restriction Fragment Length Polymorphism (RFLP)** is a technique that shows variations in homologous DNA sequences that in turn individualizes it. The DNA sample is broken into pieces and is further assimilated by restriction enzymes and then the DNA fragments are separated according to their lengths by gel electrophoresis. RFLP analysis was the first DNA profiling technique that was created by Sir Alec Jeffreys as a method of identifying individuals from their DNA. In 1986, Jeffreys used this method to help the authorities identify Colin Pitchfork as the murderer of two young girls in the English Midlands. Although RFLP was a breakthrough in the field of DNA fingerprinting, it is not ideal in Forensics, because it requires large amounts of DNA samples, which is not common in most at most crime scenes, where small degraded samples are the

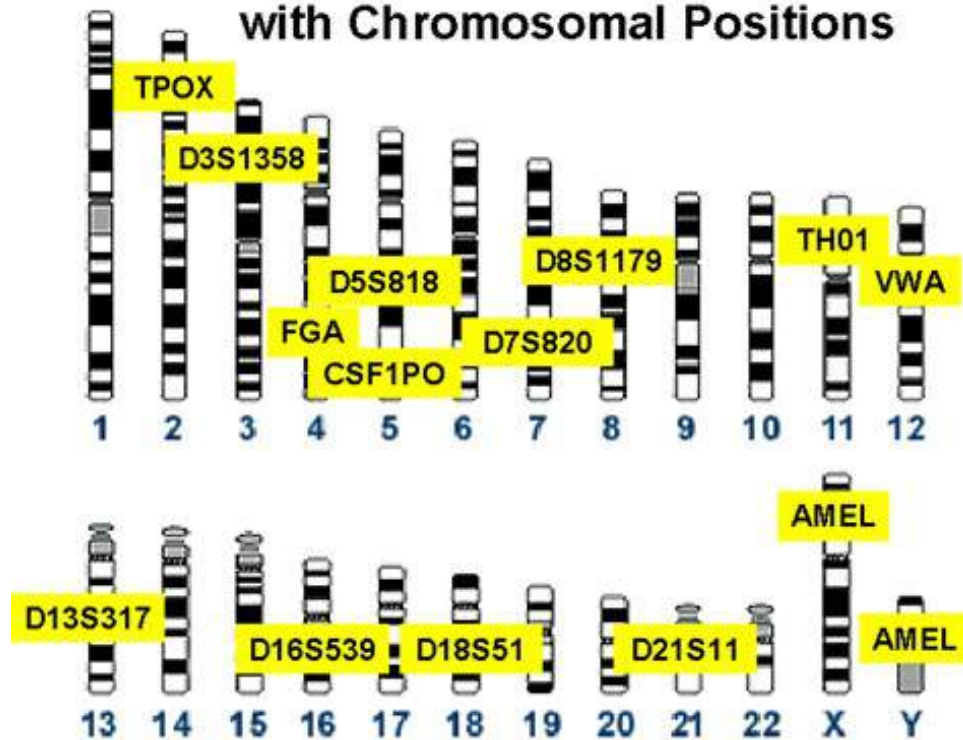
reality.

PCR : Polymerase Chain Reaction

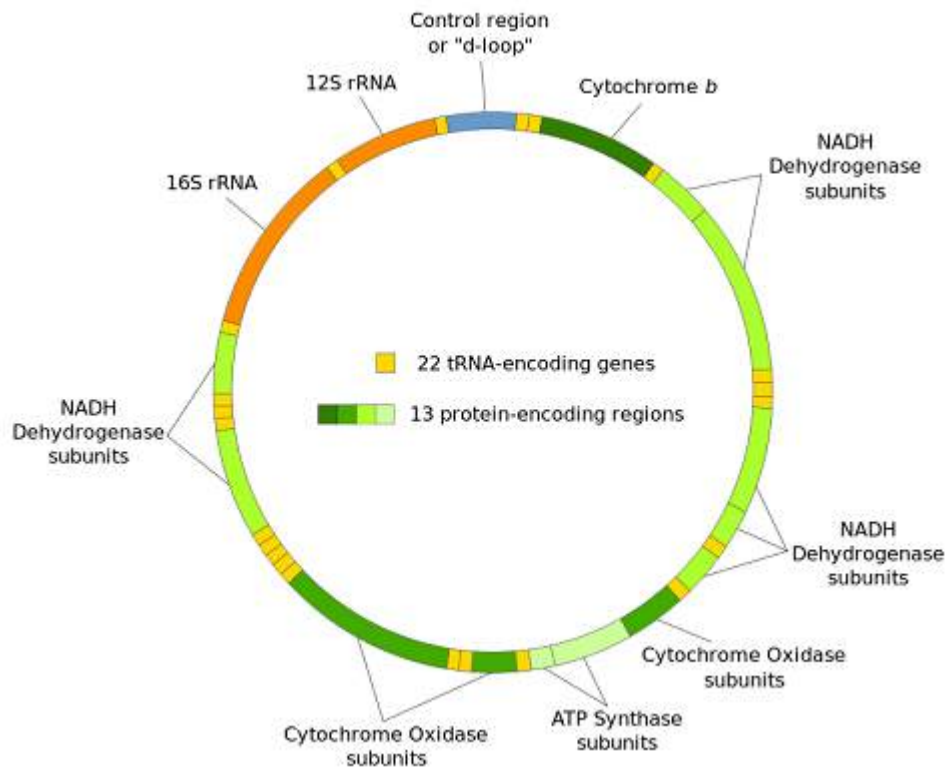


- The **polymerase chain reaction (PCR)** is used to amplify a single copy or a few copies of a piece of DNA generating thousands to millions of copies of that particular DNA sequence. This enables analysis of DNA samples even from very small amounts of starting material, like examining the DNA from cheek cells in saliva found on a glass. PCR is prone to error, therefore technicians must be very careful about contamination, which can cause mutations in the DNA fragments.

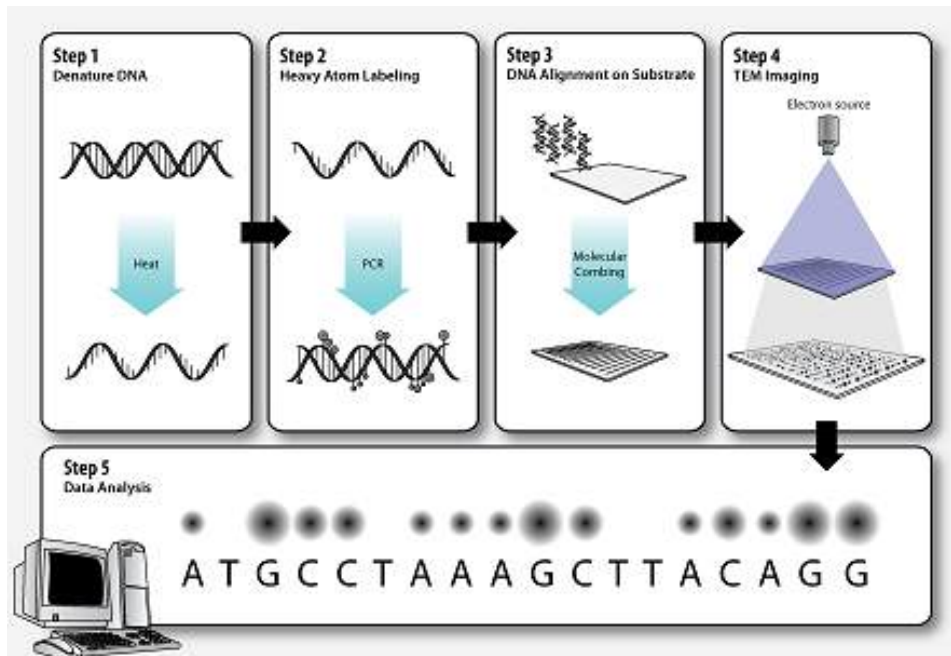
13 CODIS Core STR Loci with Chromosomal Positions



- **Short tandem repeat analysis (STR)** is a relatively new technology that for the most part has replaced RFLP analysis. It is used to compare specific loci on DNA from two or more samples. STR analysis measures the exact number of repeating units on a DNA strand. Unlike RFLP which requires a large amount of non-degraded DNA, STR analysis can be done on less than one billionth of a gram of DNA (like a single flake of dandruff). Therefore it is a beneficial tool used in forensics. Since the likelihood that any two individuals (except identical twins) will have the same 13-loci DNA profile can be as low as 1 in 1 billion or less, it is a proven method to place a suspect at a crime scene by identifying the DNA that he or she left behind.

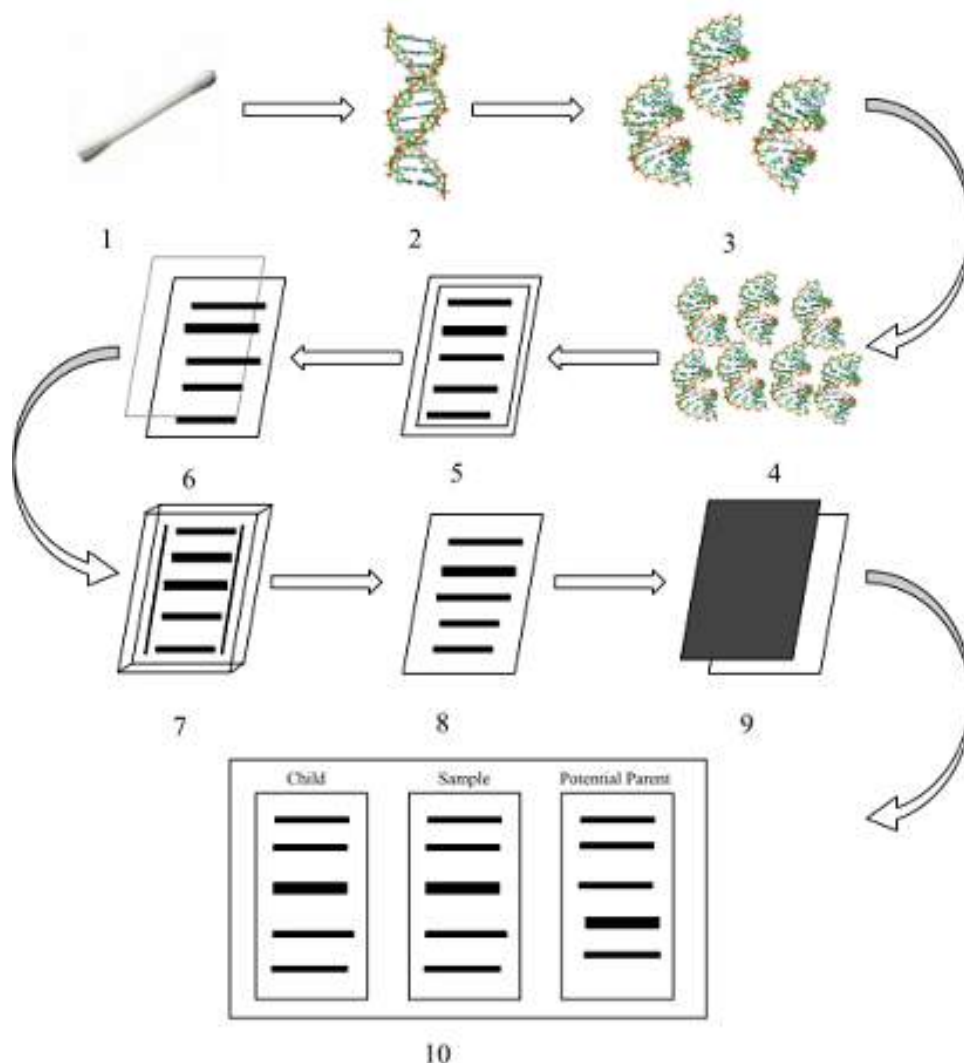


- **Mitochondrial DNA Analysis (MTDNA)** is used for samples that cannot be analyzed using RFLP or STR because of degraded nuclear DNA. MTDNA uses DNA extracted from the mitochondrion. MTDNA has a higher number of copies than does nuclear DNA and therefore is very useful in cases where the samples are old and or degraded. It has been used to identify the remains of bones found in ancient grave sites and in old cold cases. One example is the identification of the Romanov family and in particular Tzar Nicholas II of Russia after decades after their assassination.



- **Electrophoresis**

In this process DNA molecules are cut by restriction enzymes into fragments of various sizes and are forced to move along a gel-coated plate under the influence of an electrical potential. After the fragments have “migrated” across the gel, the gel can be stained to show the bands or fragments easily. Comparisons can then be made such as comparing a suspect’s DNA to the DNA found on a crime scene



How is a DNA Profile Created?

DNA profiling is a forensic technique used to identify individuals by their DNA. DNA profiling is as unique as someone’s fingerprint. It all starts with a sample of someone’s DNA, like a buccal swab. Other possible samples for DNA extraction include blood, saliva, semen, and any other body tissue. If it is impossible to obtain a sample from a suspect or when trying to identify human remains, samples obtained from blood relatives can provide an indication of an individual’s profile.

The actual process of creating a DNA profile begins with a reference sample is then analyzed to create the individual’s DNA profile using one of a number of techniques, like PCR. Once the sample is taken from the individual and then taken to the lab where the DNA is extracted from the cells and then broken down by a restriction enzyme into small fragments that are amplified by the PCR which results in many duplicate fragments. The DNA fragments are separated by electrophoresis and then transferred to an agar plate. Once placed onto the agar plate, specific DNA fragments are bound to a radioactive DNA probe. After this process an x-ray film is used to detect a radioactive pattern. This pattern is an actual DNA profile that then can be compared to other samples to find a match. If there are no suspects, a national database called CODIS may be used to find potential suspects.



CODIS

This acronym stands for Combined DNA Index System, and is the generic term used to describe the FBI's program of support for criminal justice DNA databases as well as the software used to run these databases. The National DNA Index System or NDIS is considered one part of CODIS, the national level, containing the DNA profiles contributed by federal, state, and local participating forensic laboratories. It uses 13 loci regions to look for matches at more than one location on a genome for more accurate results. It is an extremely powerful investigative tool, linking crimes, and suspects to those crimes.

Conclusion

In Conclusion, DNA is unique to each individual as is a fingerprint, Furthermore it is the blueprint that makes up both the genotype and phenotype of each individual. The primary unit that is identified is called a gene, which contains DNA.

DNA is a molecule comprised of repeating units called nucleotides. Each nucleotide consists of a Deoxyribose sugar, a Phosphate, and a nitrogen base (adenine, guanine, cytosine, thymine). The DNA structured in a double helix with sides consisting of alternating sugars and phosphates and the rungs representing the nitrogen bases. It is important to note that adenine bonds only to thymine and guanine bonds only to cytosine and that the order of the bases determines the genetic code

The process of DNA typing involves the conversion of DNA into a series of bands that can distinguish an individual. Since only a small percentage of DNA differs from one person to the next, it is these differences that are used to create a DNA profile.

Videos

The Case Against DNA Evidence

<https://www.youtube.com/watch?v=fXsn5VoKokg>

DNA Fingerprinting

<https://www.youtube.com/watch?v=drC7rR7CIBg>

All Signs Point to Innocent

<https://www.youtube.com/watch?v=Fz6p8EgJZ3w>

DNA Fingerprinting Review Questions:

1. There are _____ different nitrogen bases found in DNA.

2. The national database of DNA that stores profiles from convicted offenders, unsolved crime scene evidence, and profiles of missing persons is called _____.
3. DNA evidence should be packaged in a _____ bag or well-ventilated box.
4. _____ is a technique used for making many copies of a specific piece of DNA.
5. _____ DNA is only inherited from the mother.
6. _____ always bonds to thymine and _____ always bonds to cytosine in DNA.
7. _____ are less susceptible to degradation and can be recovered from badly decomposed circumstances.
8. A dried blood stain must be removed by using a _____.

True or False

9. _____ Always photograph evidence before collecting it.
10. _____ The PCR technique can make many, many copies of DNA.

CONCEPT

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Unit 12 Human Remains

Unit 12 Human Remains

TEKS

- Collect and organize qualitative and quantitative data and make measurements with accuracy and precision using tools such as calculators, spreadsheet software, data-collecting probes, computers, standard laboratory glassware, microscopes, various prepared slides, stereoscopes, metric rulers, electronic balances, gel electrophoresis apparatuses, micropipettes, hand lenses, Celsius thermometers, hot plates, lab notebooks or journals, timing devices, cameras, Petri dishes, lab incubators, meter sticks, and models, diagrams, or samples of biological specimens or structures. [2F]
- Analyze, evaluate, make inferences, and predict trends from data. [2G]
- Communicate valid conclusions supported by the data through methods such as lab reports, labeled drawings, graphic organizers, journals, summaries, oral reports, and technology-based reports. [2H]
- In all fields of science, analyze, evaluate, and critique scientific explanations by using empirical evidence, logical reasoning, and experimental and observational testing, including examining all sides of scientific evidence of those scientific explanations, so as to encourage critical thinking by the student. [3A]
- Evaluate the impact of scientific research on society and the environment. [3D]
- Evaluate models according to their limitations in representing biological objects or events. [3E]
- Research and describe the history of science and contributions of scientists. [3F]
- Analyze the role of scientists such as forensic pathologists and anthropologists as they relate to a homicide investigation. [5A]
- Identify the major bones of the human skeletal system. [15A]
- Compare composition and structure of human bones with other animals. [15B]
- Describe the techniques used to excavate bones from a crime scene. [15C]
- Determine unique characteristics of the human skeletal system such as gender and age. [15D]
- Explain the role of dental records in identification of remains. [15E]
- Explain the process and timeline of rigor mortis and its role in calculating time of death. [16A]
- Explain post mortem lividity and its importance when processing a crime scene. [16B]
- Determine time of death using entomology. [16C]
- Determine time and cause of death through case studies. [16D]



Introduction

Forensic Pathology and Forensic Anthropology can be essential in criminal investigations, especially in homicides. Both these departments play an important role in being able to identify human remains and their cause of death.

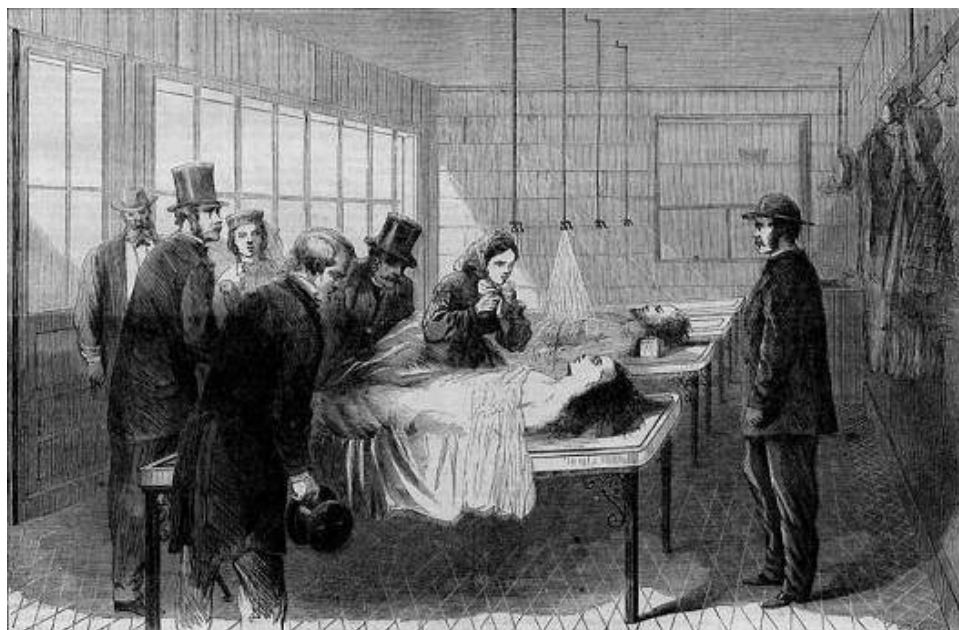
An autopsy is a post mortem examination performed on a corpse to determine the cause and manner of death, usually when the victim is suspected of dying as the result of foul play. An autopsy is performed by a medically trained professional, like a pathologist and or Medical Examiner.

Forensic Anthropology is concerned with the identification and examination of human skeletal remains within the scope of a legal investigation. These remains can possibly reveal a person's approximate age, sex, race, height, and physical injury.

Objectives

The student will be able to:

1. Analyze the role of forensic pathologists and forensic anthropologists in investigations.
2. Review the Standard terms for anatomical terminology to include planes of references, cavities, and all of the major bones of human skeletal system.
3. Compare the composition and structure of human and animal bones.
4. Describe the techniques used to excavate bones.
5. Determine the unique characteristics of an individual (such as age, gender, race, and height) from his or her bones.
6. Explain the role of Forensic Odontology.
7. Explain the processes and timelines of human death and decomposition.
8. Identify characteristics of Forensic Entomology.



Forensic Pathology

A Forensic Pathologist is a specialist who determines the cause and manner of death of the deceased. This profession dates back to the middle ages where autopsies were performed to establish cause of death. These autopsies were well documented and aided doctors of the time to learn more about the human anatomy.

A Forensic Pathologist assists law enforcement agencies, by examine the unexpected, sudden, or violent deaths of a victim or victims. Their primary role is to determine the cause, mechanism, and manner of death.

Human Death

If an unexplained death has occurred, the following must be determined Cause, Manner, and Mechanism. The cause of death can be from any of a variety of diseases or from some type of injury that results in the death of an individual. The manner of death is the reason why the death has occurred. Examples for manner of death include accidental, homicidal, suicidal, and natural causes. The mechanism of death is defined as the immediate physiological breakdown of the human body that results in death.

Once the individual has expired the body goes through five stages of decomposition; fresh, bloating, active decay, advanced decay, and the dry remains.

- Fresh: this stage occurs right after death, where the blood begins to pool to the lower parts of the body due to gravity.
- Bloating: this is the process of the anaerobic activity causing gasses to build up and giving the corpse a swelled bloated appearance. This process is caused by bacteria living within the body. It can cause the body to leak out fluids from its orifices.
- Active decay: During this stage the bacteria and maggots break through the skin. There is an unpleasant odor from the breakdown of tissue of the human body. The corpse reduced to about 20% of its original mass. It is important to note that at this stage the maggots begin to pupate.
- Advanced decay: At this stage the carcass has been reduced to hair, skin, and bones. The fly population has been reduced and replaced by other arthropods like beetles who feed on the remaining tissue and other predatory insects who may feed on the beetles or any remaining maggots and flies.
- Dry remains: In the final stage of decomposition, the carcass is left with its skeletonized form in an ideal situation, but since the corpse is usually relegated to environmental factors like humidity the carcass may take longer to decay to its skeletonized form.



What is an Autopsy?

It is a post mortem examination preformed on a corpse to determine the cause and manner of death. Forensics autopsies are preformed when the cause of death of a victim may be a criminal case, often involving foul play. A forensic autopsy is usually performed by a forensics pathologist or medical examiner. To be a pathologist, the doctor must have completed a 4-year undergraduate program, four years of medical school training, and three to four years of postgraduate training in the form of a pathology residency.

The physical examination of the body is divided into two parts. External examination and internal examination. The

external examination consists of inspecting the physical outer layer of the body for signs of foul play that would result in injury or death.



The External examination consists of reviewing the body for any wounds, like Lacerations, abrasions, bruises and or puncture wounds.

This process usually begins with Photographing the entire body in order to have a record of all external components before the removal of samples and internal examination occurs. Then a thorough examination is conducted to reveal any wounds that may appear on the body and give clues as to what happened. All physical evidence collected off body, including samples of hair, nails, and any other transfer evidence that may appear on the body are collected. Finally the body is cleaned and a secondary inspection is performed to look for any lacerations, abrasions, bruises, and punctures that may have been missed during the first inspection due to size or clarity for example.



The internal examination consists of inspecting the internal organs of the body for evidence of trauma or other indications of the cause of death.

The most used incision used for an internal examination is the “Y” incision. It is started at the top of each shoulder and runs down the front of the chest to the xiphoid process of the sternum and then a straight incision along the midline of the body to expose the lower region of the abdominopelvic cavity. Another method used is the “T” shaped incision made from the tips of both shoulders in a horizontal line and then a straight incision along the midline of the body to expose the lower region of the abdominopelvic cavity.

After either incision has been performed on the corpse, all of its organs are removed in sections. Organs are divided into four groups and removed in sections, usually according to corresponding cavity. All removed organs are weighed and examined for unusual markings or signs.

For a brain examination, an incision is made from a point behind one ear, over the top of the head, to a point behind the opposite ear. The scalp is then pulled away from the skull, creating two flaps. The front flap goes over the face, the rear flap over the neck. The skull is then cut with an electric saw to create a cover that can be pulled off to expose the brain. The brain is then cut from the spinal cord and lifted out of the skull for further examination.



Dissecting the Human body:

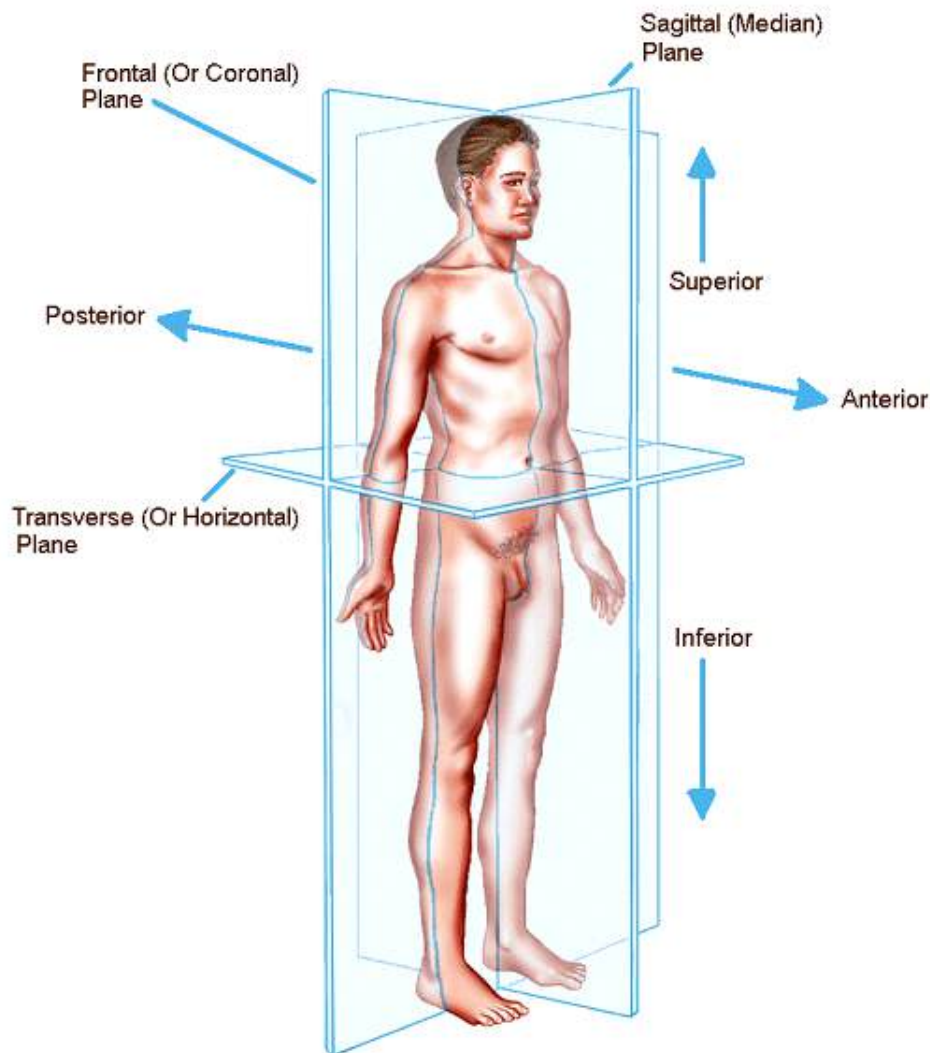
Before performing an autopsy, one must learn and understand the human body. The body is split into two areas the Axial Portion (head, neck, and trunk) and the Appendicular Portion (arms & legs). Within these two divisions of the human body we find several body cavities that are layered by membranous tissue like the serous membrane which contain a variety of organs and organ systems referred to as Viscera (internal organs) which are lubricated by serous fluid.

Cavities of the Human body:

- **Cranial cavity:** contains the brain
- **Dorsal cavity:** contain the bones of the skull that are towards the posterior side of the body as well as the vertebral column.
- **Ventral cavity:** it is the anterior side of the human body, and is divided by the thoracic and abdominopelvic Cavities.
- **Thoracic cavity:** is primarily composed of the chest area which contains the esophagus, trachea, lungs, heart, and other smaller endocrine glands.
 - **Pleural cavity:** surrounds both lungs as well as the pericardial cavity.
 - **Pericardial cavity:** surrounds the heart.
- **Abdominopelvic Cavity:** is the area containing both the abdominal and pelvic cavities separated by an imaginary line at the top of the pelvic bones. The abdominal cavity
- **Abdominal cavity:** contains the stomach, liver, gallbladder, pancreas, spleen, kidneys and both the large and small intestines. It is important to note that this cavity also holds the ovaries in females.
- **Pelvic cavity:** contains the colon, rectum, urinary bladder, the uterus found in females, and the male genitalia.

It is important to note that a thin muscle layer called the diaphragm separates the thoracic and abdominopelvic region.

When understanding the human body the purpose of an autopsy the anatomical position, Planes of the body and the anatomical terminology are crucial in identifying the parts of the body. When referring to anatomical position for an autopsy the body is face forward with its arms at the side of the body and the palms facing forward.



Planes of the body:

- **Transverse Plane:** refers to the horizontal view of the body
- **Sagittal Plane:** refers to the medial view of the body
- **Coronal Plane:** refers to the frontal view of the body

During the examination the medical examiner will use anatomical terminology when explaining the procedure for documentation.

Standard terms for anatomical terminology:

- **Superior:** position above
- **Inferior:** position below
- **Anterior:** front of the body
- **Posterior:** back of the body
- **Medial:** position that is closer from the midline of the body

- **Lateral:** position that is further from the midline of the body
- **Proximal:** position that is closer from the trunk of the body
- **Distal:** position that is further from the trunk of the body
- **Superficial:** describes structures that are close to the surface
- **Deep:** describes structures that are further away from the surface
- **Cranial:** describes structures close to the top of the skull
- **Caudal:** describes structures that are towards the bottom of the bottom of the body



Types of Mortis

Mortis comes from the Latin word Mors Mortis which means death, therefore the following are descriptions of changes in the human body after death.

- **Algor Mortis:** Is the change of body temperature after death. A rectal thermometer is used to find the temperature after death. The cooling of the body is approximately 2° Celsius the first hour and 1° Celsius an hour after.
- **Rigor Mortis:** Rigor Mortis is the recognizable stiffening of the corpse due to the lack of chemical reactions in the skeletal muscle that ceases after death. The phenomena appears up to 2 hours after death and Peaks at about 12 hours after death. It usually takes about 12-24 hours for entire rigor mortis effect to take place. The corpse will regain its flexibility at about after the first 24 hours.
- **Pallor Mortis:** is the paleness of the body that occurs after death as the blood leaves the body and sinks, creating Livor Mortis. This process is relatively quick (within the first 15-30 minutes depending on the color of the deceased).
- **Livor Mortis:** the condition that happens after death where the blood settles to the lower parts of the body due to gravity. This causes a discoloration in the skin (usually a purplish red hue) coloration of the skin after death and can be measured and used to determine approximate time of death.



Forensic Anthropology

Forensic Anthropology is the identification and examination of skeletal remains at a potential crime scene to try to establish time and cause of death of an individual. In that department the Forensic Anthropologist is the one who examines the skeletal, decomposed, or charred remains in an attempt to identify a body or possible cause of death.

Forensic anthropology was established in 1878 by Thomas Dwight, who published an essay on how to use parts of skeletal remains to establish age, sex, or height. He is today known as the father of Forensic Anthropology. There have been many more contributions to forensic Anthropology since 1878, but none have brought as much insight to death and the factors that affect the decomposition of the body as Dr. William has done with his introduction of the “Body Farm” in 1971 at the University of Tennessee. The “Body Farm” is a large area that is closed off and is the home too many corpses laid across the land at different stages of decomposition. This has enabled researchers to learn how the body decomposes and at what rate, and also takes into account how the seasons may slow or accelerate the decomposition rate.



What do the Bones Say?

Skeletal remains can reveal a plethora of information to the trained individual, a Forensic Anthropologist

- If the remains are human or not

- Age (by bone development)
- Sex (by bone weight and size)
- Height (length of bones)
- Race (nose and eye socket structures)
- Any possible skeletal injuries

A forensic anthropologist may also assist:

- With autopsies to help establish cause of death
- Perform a facial reconstruction of a skull for identification
- Help search for human remains after natural and intentional disasters
- Act as an expert witness in civil and/or criminal courts

When bones are found, a forensic anthropologist will determine the answer to the following questions

- Are they Organic or inorganic?
- Are they Human bones?
- How many individuals are represented by the bones present at the scene?
- How long have the bones been at the scene?
- Can the cause of death be determined by examining the bones?
- Can the Individual be identified by examining the bones?

Factors that help identify skeletal remains

The biological identity of an individual can be determined by looking at different features of the bones that have been recovered.

To determine the age of an individual the following criteria's are used



- **Sutures** are the zigzag “cracks that can be seen on a skull and are actually the areas that have fused together since their separation as an infant. The older an individual becomes the less visible are the suture lines, therefore measuring the width of the sutures can help to determine a range in the age of the individual.



Gender

- Males
 - Narrow pelvic opening with a less than 90° subpubic angle
 - Long, narrow sacrum
 - Overall larger skull
 - Pronounced brow bone and jaw (square)
 - robust skeleton



- Females
 - Larger, circular pelvic opening with a greater than 90° subpubic angle
 - Wide sacrum
 - Smaller skull
 - Diminished brow bone and jaw (round)
 - slender skeleton



Race Determination is divided into 3 categories

- **Asian and Native American Descent**
 - Flat or projected outward frontal plane
 - Small, rounded nasal cavities
 - Circular eye orbits
- **European Descent**
 - Flat cranium
 - Long, narrow nasal cavities

- Oval eye orbits

- **African Descent**

- Cranium projected outward
- Wide nasal cavity
- Square eye orbits

Height Determination

This is calculated by measuring the long bones, like the femur, tibia and the humerus. The calculations are based on equations that are different depending on the bones used, the race of the individual and their gender.



Other Determining Factors

- creating facial reconstructions from skulls to help identify the individual
- identifying past surgeries and or broken bones to help identify the individual
- Trauma on bone like bullet holes or other tool marks that may identify the weapon used.



Excavation of Skeletal Remains

- When excavating skeletal remains from any area it is important to follow the following guidelines to ensure the preservation of the evidence and to minimize contamination.
- Remove any debris, lime and or vegetation if present
- Tape off and sketch the excavation area
- Determine where the grave is situated, when removing the soil; sift each layer to make sure all evidence is recovered
- Document the excavation by photography, mapping the area, a complete inventory, and all measurements taken at the site. Also make sure to have a complete written record of the entire excavation process
- Removal of the skeletal remains will begin with the individual packaging of every bone of that individual. In the case of mass burials the bones will still be collected individually and inventoried together corresponding to the grid at which they were originally collected



Forensic Odontology is the study of the examination and evaluation teeth for the purpose of identification and use as evidence in a court of law. A forensic odontologist is responsible for the identification of human remains, the estimation of age depending on the maturation of the teeth discovered, and the identification of a suspect through bite mark injuries through:

- Observing the deciduous teeth in children and wear patterns in older adults
- Compare teeth to dental records
- Examine teeth for DNA
- Teeth are harder to destroy in a fire than are bones
- Examine the bite mark patterns found and compare to known samples

Bite marks are usually seen in cases involving sexual assault, murder, and child abuse. Biting can be a sign of the suspect wanting to show dominance or its victim or it can be an attempt from the victim to defend itself from the suspect.



Forensic Entomology

The determination of the time or site of death can be based on identification of arthropods collected from or near corpses. This is the basis for Forensic Entomology, which is the study of arthropods and their life cycles to determine how long a body has been deceased. Insects that feed on dead tissue, will usually appear on a corpse within the first 24 hours. The most common of these necrophilous insects is the blow fly. The flies can be recorded within different stages of their lifecycle; eggs, larvae, pupae, and adults. The stages of growth from egg to adult fly may vary due to environmental factors, but for the most part the development from the egg to the larvae (maggot) is about 23 hours, from small maggot to adult maggot is 48 hours (23 hours to doubling the size and another 25 hours to full adult size), from adult maggot to full pupae takes about 130 hours, and from pupae to adult fly takes another 142 hours. There are several types of beetles that can either be necrophilous or predatory on other insects that are residing within or on the corpse. As mentioned earlier the timeframe for the lifecycle development is heavily influenced by environmental conditions such as climate, weather, geographical location, and drugs/or toxins present in the body.



Conclusion

There are significant differences between a forensic pathologist and a forensic anthropologist. For example forensic pathologists mostly focus on victims of immediate death and collect information from the soft tissue that is examined. On the other hand forensic anthropologists mostly focus on the skeletal remains of the individual. Another difference between both disciplines is that a forensic pathologist's primary concern is the cause and manner of death of the victim, whereas a forensic anthropologist's primary concern is the identity of the victim. Finally a forensic pathologist has the legal authority to perform autopsies and state the cause and manner of death and a forensic anthropologist can analyze the skeletal remains of an individual with permission and can only present their professional opinion in an academic setting, court trial, and or other legal proceeding.

Although there are significant differences between both departments and for that matter professions they do both overlap in some key areas. First of all they both focus on death and the decomposition rate of the human body be it flesh or bone. Another key similarity Pathology and anthropology share is that they both focus on determining the time of death of the individual. They also collaborate when searching for evidence, like wound markings on either flesh and or bone.

In retrospect it is clear that forensic pathologists and forensic anthropologists are to very different fields, but they do share key factors that enable them to work together in order to help on cases when called upon.

Videos

What Happens In An Autopsy?

<https://youtu.be/l2D6H88mQC0>

Power of the Bones

<https://youtu.be/7cogeHybySI>

What happens when you die?

<https://youtu.be/nqOITqLfnc>

Human Remains Review Questions

1. What does medico-legal mean?
 - a) An autopsy is performed
 - b) Medical science is applied to law
 - c) Laws restricting medical procedures
 - d) None of the above
2. Which of the following would be considered a cause of death?
 - a) Exsanguination
 - b) Suicide
 - c) Gunshot wound
 - d) Undetermined
3. Which of the following is an example of a mechanism of death?
 - a) Exsanguination
 - b) Suicide
 - c) Gunshot wound

d) Undetermined

4. Who is considered the father of modern Pathology?

- a) GSW de Saram
- b) Thomas Dwight
- c) Rudolf Virchow
- d) Thomas Mocker

5. Who is considered the father of Forensic Anthropology?

- a) GSW de Saram
- b) Thomas Dwight
- c) Rudolf Virchow
- d) Thomas Mocker

For the following questions match the roles with the careers:

- a) Forensic Pathologist
- b) Forensic Anthropologist
- c) Both
- d) Neither

- 1. _____ Determines cause, mechanism, and manner of death
- 2. _____ Identifies someone from skeletal, decomposed, or charred remains
- 3. _____ Performs facial reconstruction to recreate what a person may have looked like
- 4. _____ Acts as an expert witness in court
- 5. _____ Performs autopsies
- 6. _____ Searches a crime scene for evidence
- 7. _____ Helps identify victims in mass disasters
- 8. _____ Issues death certificates
- 9. _____ Helps establish time since death

Short Answer

What are the 5 categories that manner of death can fall into?

