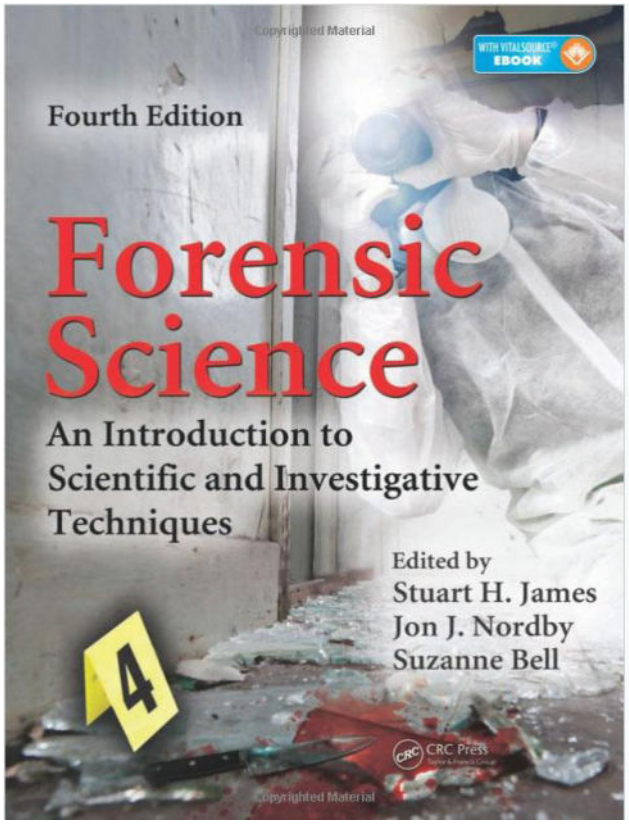

FORENSIC SCIENCE – KEY TERMS AND CONCEPTS

Study Guide for CSCSA Exam

ABSTRACT

A review of key terms as well as the end of chapter questions from the textbook. While it is strongly recommended you read the entire book, use this guide to assist you in your learning.

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FORENSIC SCIENCE: ***An Introduction to Scientific and Investigative Techniques***

Chapter 1: Justice and Science

- The hope of the American litigation system is to provide the best, fairest, and optimal context for a jury to find the truth and use that truth to settle a dispute.
- **Generalists**: Scientists that worked in many forensic disciplines.
- **Specialist**: Forensic scientists who specialize in one forensic discipline.
- **Victor Balthazard (1852-1950 French)**: Medical Examiner for Paris. Credited with developing probability models that showed that fingerprints were unique and that there is approximately one chance in 10 (60^{th} power) that any two people will have the same patterns. In 1910 he along with Marcelle Lambert, wrote the first comprehensive book on hair analysis entitled The Hair of Man and Animals. Developed an advanced photographic method of comparing markings on bullets. Was among the first to note other distinctive markings in firearms, including firing pin impressions and fabric impressions that result when a soft lead bullet passes through woven fabrics.
- **Alphonse Bertillon (1853-1914 French):** Developed the first systematic method for the identification of suspects and criminals, but it was not based on fingerprints. It was called anthropometry or Bertillonage. This system used 11 body measurements along with descriptive information and photographs to identify people. Bertillon was the first scientist in Europe to use fingerprints to solve a case.
- **Sir Francis Galton (1822-1911 English):** He is credited with developing the first classification system for fingerprints. 1892 published his book *Finger Prints*. He was the first proponent of classification using the basic patterns of the loop, arch and whorl. "Galton Ridge" used to describe features found in fingerprints.
- **Calvin Goddard (1891-1955 American)**: Credited with establishing scientific examination of firearms evidence in the US. A Dr. and gun enthusiast. He worked on many famous cases such as the St. Valentine's Day Massacre in 1929. Some of the tools used in modern firearms examination were developed by Goddard and co-workers. Assisted the FBI in establishing firearms analysis capabilities in 1932.
- **Hans Gross (1847-1915 Austrian)**: Credited with coining the term Criminalistics to describe forensic analysis of physical evidence. He viewed forensic science holistically and believed that experts from diverse fields would contribute to the analysis of physical evidence and solving crimes. He was a generalist. Understood the value of biological evidence as well as trace and transfer evidence. Published the first textbook in forensic science in 1893 titled *Criminal Investigation*.
- **Sherlock Holmes/Sir Arthur Conan Doyle**: This fictional character helped shape the public's image of forensic science. 56 short stories and 4 novellas. In *A Study in Scarlet*, Holmes

announces the discovery of a chemical reagent that detected human blood. This was 1887, 14 years before that test was actually possible.

- **Edmond Locard (1877-1966 French)**: Trained in both law and medicine. 1910 established a forensic laboratory in Lyon, France. Interested in microscopic and trace evidence and how you could link people to places. Developed Locard's Exchange Principle. In Lyon, he founded and directed the Institute of Criminalistics.
- **Mathieu Orfila (1787-1853 (Spanish, French)**: Considered the founder of forensic toxicology. Moved to France where he became a professor and then dean of the medical faculty at the University of Paris. Studied poison particularly arsenic. Testified in homicide case becoming the earliest examples of sound scientific testimony by a recognized scientific expert in a court of law.
- In Law: Judge = Finder of Fact / Jury = Trier of Fact
- **The Scientific Method** Can be thought of as a series of steps:
    - Formulate a Hypothesis (a tentative idea or explanation)
    - Test the Hypothesis using observation or experimentation
    - Base on the results, revise the hypothesis and repeat
    - Continue until the data are in agreement with the hypothesis
- **Adversarial System**: The legal system in the US. A system in which decisions are rendered based on the merit of two opposing arguments. The scientific method and the adversarial system operate with a different set of facts. The scientist may present the data, but the lawyer may argue that the data is inadmissible. Science is not flexible; it must be data centered and data driven.
- Forensic Science should:
    - Help distinguish evidence from coincidence.
    - Allow alternative results to be ranked by some principle basis to the sciences applied.
    - Allow for certainty and probabilistic considerations wherever appropriate through this ranking of relevant available alternatives.
    - Disallow hypotheses more extraordinary than the facts themselves.
    - Pursue general impressions to the level of specific details.
    - Pursue testing by breaking hypotheses (alternative explanations) into their smallest logical components, addressing one part at a time.
- **Fallibilism:** An awareness of how much we do not know and the humility to acknowledge the possibility of making mistakes. Forensic scientists must develop an intellect not too sure of what must remain uncertain and not too uncertain about what must remain sure.
- **Public Laboratories:** Are those funded by governments such as states, counties and cities.

- **Private Laboratories:** Are businesses that are designed to make a profit; most of these labs specialize in DNA and forensic toxicology.
- **Accreditation:** A laboratory has agreed to operate according to a professional or industry standard and has proven that it can and does operate this way. Accreditation is one of the most important developments in forensic science labs recently.
- **Certification:** A forensic scientist has completed a written test covering his/her discipline and that the analyst participates in yearly proficiency testing to ensure that their laboratory methods and techniques are sound.
- **Trier of Fact:** The individual who evidence is presented to and who will make the decision based on the evidence presented. This will either a judge or jury.
- **Grand Jury**: Is a special type of jury that is empowered to decide if the evidence against a defendant warrants proceeding to the next step. If there is then they will "hand down an indictment."
- **Voir Dire**: The process by which an expert is questioned to determine whether or not he/she will be accepted as an expert by the court.
- **Prosecutorial Bias**: The potential tendency of a forensic scientist to make scientific determinations that favor the prosecution.

Chapter 1 Review Questions:

1. **The systems of science and the law have two different purposes. Summarize these in your own words.** The scientific method and the adversarial system (legal system) operate with a different set of facts. The scientist may present the data, but the lawyer may argue that the data is inadmissible. Science is not flexible; it must be data centered and data driven.

2. **What type of incident was the most important in driving the initial development of forensic science?** Criminal cases such as homicides where the individual that committed the crime needed to be caught and punished as well as the innocent being released if arrested falsely.

3. **What is the difference between a forensic generalist and a forensic specialist? Name two forensic specialties that you have heard of**. Generalist is a scientist that worked in many forensic disciplines. A specialist takes one discipline and learns/studies this one discipline only. Example: Footwear/Latent print examiners.

4. **List the forensic scientists that were involved in the early development of fingerprints. What made fingerprints so important to forensic science at the turn of the 20th century?** Bertillon was the first to use fingerprints in a court case and identify someone in a homicide case which solved the case. Galton: came up with the first classification system for fingerprints. He differentiated/named the loop, arch and whorl.

5. **What would you expect to be the biggest disadvantages to the Bertillon system of identification of individuals?** The variation of measurements made by the people taking the measurements. If they did not have the same rulers/measurements would be off. People body parts change so not all measurements would stay consistent. How to file them with all the different changes in the measurements would also be an issue.

6. **What is the fundamental characteristic of an adversarial system such as the law?** Two sides arguing different points of the case trying to win for their client. The process is an argumentative type of system where either a judge or a jury are the individuals that eventually decide the case. Evidence and witnesses are called to prove a side.

7. **What are the differences between public and private forensic laboratories?** Public are non-profit labs, governed and funded by the government agencies they reside in. Private are profit oriented. They will mainly work on DNA cases and testifying in court where they are paid witnesses.

8. **What is the difference between accreditation and certification?** Accreditation is done to the lab itself. The lab goes through a strict set of protocols and standards that they have to meet and continue to operate under. Certification is done by an individual that works in the lab. They are tested in their area of specialization as well as given proficiency tests yearly to make sure that they maintain their level of expertise. They also have to maintain a certain number of hours of training yearly to retain their certification and recertify every five years or so.

9. **What process is used by the trier-of-fact and the courts to determine if a scientist is qualified to offer expert testimony in a given case?** They put the witness through Voir Dire. This is where the expert is questioned to determine whether or not he/she will be accepted by the court. They talk about their years of experience, training, number of cases they have done, etc. If the judge believes that they have passed this process they will be deemed an expert and allowed to testify as such.

10. **You are a new fingerprint examiner hired to work in a forensic laboratory. You have been trained in fingerprint evaluation and have a degree in forensic science. One day, your supervisor brings you a case file and asks you to see if you agree or disagree with his identification of a fingerprint. You study the case and come to the conclusion that the senior analyst was incorrect. When you discuss this with him, he becomes angry and refuses to reconsider his findings. What do you do, and why?** You go to this supervisors supervisor and discuss the issue with them. Tell them what happened and how it was handled and have a second set of eyes look at the fingerprint comparison. If you are just beginning a training course you should not be examining/verifying anyone's work that has more experience than you do. They might be testing you to see how you handle these types of situations as well.

Chapter 2: Evidence: Origins, Types, and Admissibility

- **Rules of Evidence**: Generally, the rules used by a court to determine if scientific evidence will be admitted.
- Forensics and other types of evidence are used to reconstruct the events that encompass the crime being prosecuted.
- Forensic science involves the application of scientific theory accompanied by laboratory techniques.
- Forensic science and forensic scientists generate data, reports, and opinions that all can be used as evidence, but only if the court allows such evidence to be admitted in the first place. Admissibility needs a *FOUNDATION*.
- A foundation consists of sufficiently supportive information presented to a judge to convince him/her that the proposed witness or item of information has the potential to be true, and hence a jury could reasonably determine that it is or is not true.
- **Admissible Evidence**: Must be reliable and relevant to the case at hand, and for scientific analysis, the court must be assured that the methods used are scientifically acceptable and reliable.
- **Frye v. United States (1923):** Rejected the validity of the polygraph. A standard applied in some jurisdictions to the admissibility of scientific theory and method in court based upon the acceptance of the theory and method by the scientific community; **"General Acceptance."**
- **Federal Rules of Evidence (1975)**: Federal guidelines designed to guide federal courts in determining if scientific evidence is admissible. A committee was formed at the request of the U.S. Supreme Court to fix the areas where the Frye standard was not working.
- **Rule 702 "Testimony by Experts"**: *If scientific, technical, or other specialized knowledge will assist the trier of fact to understand the evidence or to determine a fact in issue, a witness qualified as an expert by knowledge, skill, experience, training, or education, may testify thereto in the form of an opinion or otherwise.*
- **Daubert v. Merrell Dow Pharmaceuticals (1993):** A landmark case regarding admissibility. General acceptance is not an absolute requirement for determining admissibility; rather, it is the responsibility of the trial judge to determine if scientific evidence is relevant and reliable. Judge becomes the "Gatekeeper." The judge will determine:
    - **General acceptance**
    - **Peer review of technique**
    - **Standards for the method (**scientific methodology**)**
    - **Validation of the method** (repeatability)
    - **Potential errors** (error rates)
    - **Testable**

- **Daubert Trilogy (late 1990's):** Judge is gatekeeper.
  - **Daubert v. Merrell Dow Pharmaceuticals**: Family sues because a baby was born with birth defects due to the medicine given to the mother for morning sickness. Scientific evidence is critical; general acceptance is not absolute requirement.
  - **General Electric Co. v. Joiner**: Employee sued because cancer was due to chemical exposure at work. Requested that the animal testing where cancer occurred be allowed in court. It was rejected because the study did not directly apply to or have realistic conditions. The scientific data had to pass the Daubert criteria as well as a relevance test before it could be admitted.
  - **Kumho Tire Co. v. Carmichael**: Civil case where death occurred from tire failure. Court ruled that the testimony offered by the engineer fell under the umbrella of scientific expert.
- **Inculpatory/Exculpatory**: A piece of evidence can include or exclude a person as a source and thus tend to incriminate or exonerate him/her.
- **Direct/Circumstantial Evidence**: Direct evidence establishes facts directly-eyewitness testimony. Circumstantial (forensic evidence) evidence requires the trier of fact to infer certain events linking a defendant to DNA at a crime scene.
- **Reconstruction Evidence**: Provides information about the events preceding, occurring during, and occurring after the commission of a crime. Reconstruction of a crime takes observation, logic, experience, and evaluation of statements by key witnesses.
- **Associative Evidence**: Items that are considered of unknown or questioned origin until a comparison is made to a known standard or exemplar. Associative evidence can be further subdivided into:
  - Class Evidence
  - Identification Evidence
- We can categorize evidence by its scientific grouping:
  - Biological Evidence
  - Chemical Evidence
  - Trace Evidence
  - Fingerprint Evidence
  - Impression Evidence
  - Firearm Evidence
  - Tool Mark Evidence
  - Questioned Document Evidence

Chapter 2 Review Questions:

1. **The rules of evidence are exclusionary. Explain what this means**. They are the rules used by a court to determine if scientific evidence will be admitted. The evidence must be reliable

and relevant to the case at hand and the court must be assured that the methods used are scientifically acceptable and reliable. If they are not tested, peer reviewed, standards, validated, then the evidence and the testimony of the expert will be excluded, not allowed in.

2. **A bloody towel is recovered at a homicide scene. Describe the *forensic* and *evidence* characteristics of this towel**. The forensic part refers to the scientific processes through which facts are generated. Ex: how the DNA is extracted, tested and subjected to population analyses. Science addressed in product liability and environmental civil cases does not lend itself to such finite boundaries. There is much less of an opportunity to discuss the general outlines of acceptable methodology in the arena of civil law.

3. **What kind of foundation would be needed for the towel described in the previous question to be admitted as forensic evidence?** Photographs or a witness giving testimony would have to be used to establish where the evidence was found and/or located at. If someone has knowledge of who the towel belongs to they would also need this person to testify. The chain of custody with the towel would also have to remain unbroken and the evidence would have to have been collected legally, with a search warrant, so that there was no "fruit from the poisonous tree" taking place with the case.

4. **What are the key differences between the *Frye* admissibility standards and the *Daubert* admissibility standards?** Frye a standard is applied in some jurisdictions where the admissibility of scientific theory and method in court is based upon the acceptance of the theory and method by the scientific community. The "General Acceptance" rule. Daubert the responsibility is shifted to the trial judge to determine if scientific evidence is relevant and reliable. The Judge becomes the "gatekeeper."

5. **Summarize the key components of each decision in the *Daubert* trilogy**. Daubert: scientific evidence is now controlled by the judge. General Electric v Joiner: the scientific data had to pass the Daubert criteria as well as a relevance test before it could be admitted. Kumho Tire v. Carmichael: court ruled that the testimony offered by the engineer fell under the umbrella of scientific expert.

6. **Suppose the towel mentioned in questions 2 and 3 above is found to have a mixture of blood on it. DNA analysis shows that some of the stains are consistent with the suspect and most of it is consistent with the victim. What categories of evidence described in Section 2.3 could this towel belong to?** The towel has the possibility of containing DNA evidence as well as trace evidence. It can possibly be linked back to the suspect, victim or a location. It would be considered circumstantial evidence meaning it requires the trier of fact to infer certain events linking a defendant to DNA at the scene. Unless you can have a witness stating that they saw where the bloody towel came from and who put it there and give this as direct evidence, it will remain circumstantial.

Chapter 3: Crime Scene Investigation

- **Macroscopic Crime Scene**: The overall or "big picture" crime scene.
- **Microscopic Crime Scene**: Crime scene description based on the type of physical evidence present.
- The objective of any crime scene investigation are to recognize , preserve, collect, and interpret all of the relevant physical evidence at a crime scene with the goal of reconstructing the events that generated this evidence.
- Types of information that can be obtained from forensic testing:
    - Linkage of persons, scenes, or objects
    - Investigative leads
    - Information on the corpus delicti
    - Information on the modus operandi
    - Proving or disproving witness statements
    - Identification of the suspect(s)
    - Identification of unknown substances
    - Reconstruction of a crime
- 4 distinctive but interrelated **components of crime scene management** are:
    - Information management
    - Manpower management
    - Technology management
    - Logistics management
- **First Responding Officers**: Their actions at the crime scene will form the basis for successful or unsuccessful resolution of the investigation.
- **Crime Scene Security Measures**:
    - Assist the victim and prevent any changes to the victim.
    - Search for and arrest the suspect if they are still on scene.
    - Detain any witnesses. Separate them. Do not take them back to the scene.
    - Protect and secure the crime scene. Tape off area, limit people in/out.
    - Document all movement, alterations or changes made to the scene.
- **Walk-Through**:
    - Use as a mental beginning for reconstruction
    - Note any transient or conditional evidence that needs to be protected.
    - Weather conditions, take precautions.
    - Note points of entry/exit and path through the scene that need additional protection.
    - Record initial observations like who, what, where, when and how.
    - Access the scene for PPE that will be needed.

  - Notify superior officers or other agencies as required.
- The single most important task of a crime scene investigator? Recording the conditions of the scene and documentation.
- The purpose of crime scene documentation is to permanently record the condition of the crime scene and its physical evidence.

- **The 4 major types of documentation are**:
  - Note taking
  - Videography
  - Photography
  - Sketching
- Forensic photography came of age during the killings in London attributed to Jack the Ripper (1888).
- Mug shots in Switzerland in the mid-1850's.
- The purpose of still photography documentation of the crime scene is to provide a true and accurate pictorial record of the crime scene and physical evidence present.
- **Crime Scene Mapping/Forensic Mapping**: Using techniques associated with surveying to obtain data that can be used to generate a 3D rendering and record of the scene.
- Accurate crime scene note taking is crucial at the initial crime scene investigation, but it is also essential for any subsequent investigations that may follow. These notes must be include accurate and reliable measurements of distances, locations etc.
- **3 techniques used to obtain measurements**:
  - Triangulation
  - Baseline
  - Polar coordinates
- **Search Methods**:
  - Link (one piece of evidence leads to another-most common and productive method)
  - Line/strip (line one way only)
  - Grid (line strip two directions)
  - Zone (bomb training)
  - Wheel/ray (start in center and move out like spokes in tire)
  - Spiral (start in center go around in circles)
- **Crime Scene Reconstruction**: Is the process of determining or eliminating the events that could have occurred at the crime scene by analysis of the crime scene appearance, location and position of the physical evidence, and forensic laboratory examination of the physical evidence.

- Crime Scene Reconstruction is a systematic fact-gathering process based on the scientific method. It involves a set of actions or stages:
  - Data Collection
  - Conjecture
  - Hypothesis Formulation
  - Testing
  - Theory Formulation

Chapter 3 Review Questions:

1. **What are the basic steps of scientific crime scene investigation?** Remember that not all crime scenes are alike. They are static and can change in an instant. Can have many different locations and scenes. The way that the scenes are handled should be done in the same way. Document with photos, notes, video, and sketch then collect and preserve the evidence in a way that will prevent damage or loss. The basic crime scene procedures are physical evidence recognition, documentation, proper evidence collection, packaging, and preservation.

2. **List and describe the definitions or classifications of crime scenes**. Primary Crime Scene: The site of the original or first criminal activity. Secondary Crime Scene: any subsequent crime scenes. A second classification of crime scenes is based on the size of the crime scene. A single macroscopic crime scene, such as a house, may actually be composed of many smaller or Microscopic Crime Scenes. The microscopic classification of the scene is more focused on the specific types of physical evidence found in the macroscopic crime scene.

3. **What are the four components of crime scene management?** Information management, manpower management, technology management, logistics management.

4. **What are the five crime scene investigation models**? **Describe them and give the advantages and disadvantages of each.**
   a. **Traditiona**l: uses patrol officers and detectives as crime scene technicians. Advantages: useful in resources and demand are relatively low. Disadvantages: Minimal experience and time commitment conflicts with regular duties.
   b. **Crime Scene Technicians**: Specially trained, full-time civilian personnel. Advantages: Continuity, specialization, scientific/technical training. Disadvantages: Minimal investigative experience, lack of a global view of investigation.
   c. **Major Crime Squad**: Full time, sworn officers. Advantages: primary assignment, increased experience. Disadvantages: Depletion of investigative resources due to transfers out of unit, only major cases handled.
   d. **Lab Crime Scene Scientists**: Laboratory scientists. Advantages: Superior technical and scientific skills, knowledge of current methods. Disadvantages: No investigative experience, depletion of laboratory resources.

e. **Collaborative Team**: Use of police officers, technicians, lab personnel, medical examiners and prosecuting authorities. Advantages: Advanced scientific technical, and investigative resources; shared responsibilities. Disadvantages: Extensive resources and comprehensive procedures required, with continual communication.

5. **Discuss the duties of the first responder at the crime scene**. Their actions at the scene will form the basis for successful or unsuccessful resolution of the investigation. Their duties include the following:
    a. Assist the victim and prevent any changes to the victim.
    b. Search for and arrest the suspect if that person is still on the scene.
    c. Detain any witnesses. Keep them separated to preserve objectivity. Do not take them back to the scene.
    d. Protect and secure the crime scene. Put up barrier tape. Establish a security log to record who comes in and out of the scene. This helps prevent contamination of the scene.
    e. Document all movements, alterations, or changes made to the crime scene and pass this information to the crime scene investigators.

6. **What is the multilevel approach to crime scene security?** Start with the scene barriers being out as far as you think might be necessary and then go out an additional 50 yards. Have an outer and inner perimeter as well as a staging area for technicians to place evidence collected, rest, place garbage, etc. It is easier to scale the size down then it is to take it bigger after the perimeter has already been established.

7. **What are the components or tasks of crime scene documentation? What is the purpose of each?**
    a. Note Taking: Written record of all of the crime scene activities. Memory loss is prevented because notes are taken at the time of the incident. Covers who, what, when, where and why.
    b. Videography: Provides a virtual images of the scene. It should not be narrated or contain audio. Juries expect video now. Gives an overall accurate impression of the crime scene that often cannot be accomplished by the other documentation.
    c. Photography: The purpose is to provide a true and accurate pictorial record of the crime scene and physical evidence present. It provides investigators and others with a record that can be analyzed or examined subsequent to the scene investigation, and it serves as a permanent record for any legal concerns. Follows videography.
    d. Sketching: Provides a proper perspective of the overall scene and the relevant physical evidence identified within the scene.

8. **What is the basic process used for photographing crime scenes? Discuss each step:**
    a. **Overall Photographs:** Contain two parts
        i. **Exteriors**: Surroundings, buildings, roads or paths, street signs, mail boxes, aerial when possible.

ii. **Interiors**: Use all four compass points or room corners to orient photographs; overlap views; take photographs of doors leading into and out of the structure.

b. **Mid-Range**: Follow a step-wise progression of views; use various lenses or change the focal length of the lenses to achieve a "focused" view of the individual items of evidence within the original view of the scene. Add flash to enhance detail or pattern evidence.
c. **Close-up Photography**: use documentation placards; use flash photography; use proper side lighting effects; fill in flash; with and without scales.
d. **All Photographs**: Record in log; use camera settings that achieve good depth of field; include no extraneous objects such as team members, equipment, feet or hands; change point of view; be aware of reflective surfaces; when in doubt, photograph it!

9. What are the two basic types of crime scene sketches? What are the two types of perspectives used in sketches?
a. Rough sketch and final or finished sketch.
b. Overhead (bird's eye) and elevation (side view) sketches.

10. **Describe and discuss the six types of search patterns used in crime scene investigations**.
a. **Link Method**: Based on the linkage theory; most common and productive method; one type of evidence leads to another item; experiential, logical, and systematic; works with large and small, indoor or outdoor scenes.
b. **Line or Strip Method**: Works best on large, outdoor scenes; requires a search coordinator; searchers are usually volunteers requiring preliminary instructions.
c. **Grid Method**: Modified, double line search; effective method but time consuming.
d. **Zone Method**: Best used on scenes with defined zones or areas; effective in houses or buildings with rooms; teams are assigned small zones for searching; often combined with other methods; good for search warrants.
e. **Wheel or Ray Method**: Used for special situations; has limited application; best used on small circular crime scenes.
f. **Spiral Method**: Inward or outward spirals; best used on crime scenes without physical barriers (e.g. open water); requires the ability to trace a regular pattern with fixed diameters; has limited application.

11. **What are the general guidelines for the collection, packaging, and preservation of physical evidence?** Transient, fragile, or easily lost evidence should be collected first. Different types of physical evidence will require specific or special collection and packaging techniques. Most items of evidence at the scene will be packaged into a primary container that is then placed inside a secondary container. The outer containers are then sealed, initialed, dated. Liquid or volatile items should be placed in airtight, unbreakable containers. Wet, moist, or living biological evidence should be temporarily packaged in airtight containers. Air dried, and repackaged. Each item should be packaged separately to prevent cross contamination.

12. **List and discuss the stages of crime scene reconstruction**.
    a. **Data Collection**: All of the information and documentation obtained at the scene, witnesses, etc. Includes the condition of the physical evidence, patterns and impressions, condition of the victim. This should all be reviewed, organized and studied.
    b. **Conjecture**: before any detailed analysis of the evidence is accomplished, a possible explanation of what happened at the scene may be developed. It is not fixed or the only possible explanation at this point, as there may be several other possible explanations.
    c. **Hypothesis Formulation**: Additional accumulation of data is based on examination of the physical evidence and the continuing investigation. Scene examination and inspection of the physical evidence must be carried out. Interpretation of bloodstain and impression patterns will lead to formulation of a reconstruction hypothesis.
    d. **Testing**: Once a hypothesis has been developed, additional testing or experimentation must be done to confirm or disprove the overall interpretation or specific aspects of the hypothesis. This stage includes comparison of samples collected at the scene with known standards, as well as chemical, microscopic, and other analyses and testing. Controlled testing or experimentation with regard to possible scenarios of physical activities must be done to corroborate the hypothesis.
    e. **Theory Formulation**: Additional information may be acquired during the investigation about the condition of the victim or suspect, the activities of the individuals involved, the accuracy of witness accounts, and other information about circumstances surrounding the event. When the hypothesis has been thoroughly tested and verified by analysis, the reconstruction theory can be formulated.

13. **What is the purpose of a walk-through?** It is the first examination or orientation of the crime scene by the investigator, and the following guidelines should be followed:
    a. Use the walk-through as a mental beginning for a reconstruction theory that can and should be changed as the scene investigation progresses.
    b. Note any transient (temporary) or conditional (the result of an action) evidence that might be present and requires immediate protection or processing.
    c. Note any points of entry or exit and paths of travel within the crime scene that may require additional protection. Be aware of any alterations or contamination of these areas by first responder personnel.
    d. Briefly record initial observations of the answers to who, what, where, when and how questions. This is not an appropriate time for a detailed description of the scene.
    e. Access the scene for personnel, precautions, or equipment that will be needed.
    f. Notify superior officers or other agencies as required.

14. **How would you package a single hair recovered from a scene?** In a pharmacists fold.

Chapter 4: Bloodstain Patterns:

- **Bloodstain Pattern Analysis**: A forensic tool that assists the investigator to better understand what took place and what could not have taken place during a bloodshed event. It's a form of crime scene reconstruction. The science of BPA in modern form emerged in the 1800s.
- **Victor Balthazard (1852-1950 French)**: Medical Examiner; helped advance fingerprint, firearms and hair analysis. Developed probability models to show the uniqueness of fingerprints (10^{60}); noted distinctive markings in firearms, including firing pin impressions and fabric impressions that result when a soft lead bullet passes through woven fabrics. *Completed original research and experimentation with bloodstains and patterns.*
- **Dr. Paul Kirk (1955):** The use of bloodstain pattern analysis as a recognized forensic discipline in the modern era dates back to him and his examination of bloodstain evidence and findings during the case of *State of Ohio v. Samuel Sheppard*. (Harrison Ford/Fugitive). Kirk worked at the University of California at Berkeley.
- **SWGSTAIN**: Scientific Working Group was formed to further develop and standardize bloodstain pattern analysis.
- **Plasma**: The fluid portion of blood that contains cellular components consisting of red blood cells, white blood cells, and platelets.
- **Serum**: The portion of blood that does not clot.
- Red Blood Cells=Erythrocytes
- White Blood Cells=Leukocytes. Nuclei of the WBC's are the sources of DNA in the blood.
- **Exsanguination:** A person who loses significant amounts of blood; dies by bleeding to death.
- **Surface Tension**: the force that pulls the surface molecules of a liquid toward its interior, decreasing the surface area and causing the liquid to resist penetration. The surface tension of blood is slightly less than that of water. Exposed blood is held together by strong cohesive molecular forces called surface tension.
- **Spheroid**: The shape of a blood drop in air; it is directly related to the molecular cohesive forces acting upon the surface of the drop.
- **Passive Blood Drop Creation**: Happens when the volume of the drop increases to a point where the gravitational attraction acting on the drop overcomes the molecular cohesive force of the blood source. The volume of a typical drop of blood is approximately .05 milliliters (mL) with an average diameter of about 4.5 (mm) while in the air.
- **Viscosity:** The resistance to change of form or flow. Thickness of liquid.
- **Specific Gravity**: The weight of a substance relative to the weight of an equal volume of water.

- **Terminal Velocity**: Maximum speed to which a free-falling drop of blood can accelerate in air; about 25.1 feet per second.
- It is not possible to establish with a high degree of accuracy the distance that a passive drop of blood has fallen at a crime scene, as the volume of the original drop is not known.
- **Directionality**: Established by the geometric shape of the bloodstain; parameter that indicates the direction the blood was traveling when it impacted the target surface. The narrow end of an elongated bloodstain usually points in the direction of travel.
- **Area of Convergence**: Drawing straight lines through the long axes of the bloodstains. The area where these lines converge represents the relative location of the blood source in a 2-dimensional perspective.
- **Area of Origin**: Location of the blood source in a 3-dimensional perspective.
- **Angle of Impact**: Acute or internal angle formed by the direction of a blood drop and the plane of the surface it strikes. This calculation is accomplished by dividing the width by the length of the blood stain. This ratio is the ARCSINE of the impact angle.
- After establishing the angle of impact for each of the bloodstains, the 3-dimensional origin of the bloodstain pattern can be determined. This can be done by *stringing* the area.
- The calculated area of origin is always higher than the actual origin of the bloodstains because of the gravitational attraction affecting the spatters while in flight. This gives the analyst the maximum possible height of the blood source.
- **Spattered Blood**: Is defined as a random distribution of bloodstains that vary in size that may be produced by a varied of mechanism. The quantity and size of spatters produced by a single mechanism can vary significantly. Spatter is created when sufficient force is available to overcome the surface tension of the blood. The size range of spatter produced by any one mechanism may also vary considerably.
- The identification and analysis of blood spatter patterns are significant for the following reasons:
    - Spattered blood may allow for the determination of an area or location of the origin of the blood source when the event occurred.
    - If found on a suspects clothing, spattered blood may place that person at the scene of a violent altercation.
    - Spattered blood may allow for determination of the specific mechanism by which the pattern was created.
- The size, quantity, and distribution of these spatters vary depending upon:
    - The quantity of blood subjected to the impact
    - The force of the impact
    - The texture of the surface impacted by the blood

Blood Spatter:

Secondary Mechanisms:

Satellite spatter: Small droplets of blood projected around a drop of blood upon impact with a surface; drip patterns, blood in blood.

Impact Mechanisms (Gunshot, Beating/Stabbing, Power Tool, Auto Accidents):

Gunshot: Impact spatter associated with gunshot may produce minute spatters of blood less than 0.1 mm = mist-like dispersions. Gunshot spatter may range in size from 0.1 mm to several millimeters depending on quantity of blood available, caliber of the weapon, number of shots fired, impeding factors i.e. clothing/hair.

Forward Spatter: Impact spatter associated with an exit wound.

Back Spatter: Impact spatter associated with an entrance wound.

Beating/Stabbing: Impact spatter associated with beating and stabbing events generally exhibit a size range from 1 to 3 millimeters in diameter.

Projection Mechanisms:

Cast-off: Created with subsequent blows to the same general area where blood has accumulated. Blood will adhere in varying quantities to the object that produces the injuries. When the centrifugal force generated by the swinging weapon is great enough to overcome the adhesive forces of blood, blood will be cast off the object. Can appear linear in distribution and individual stains are frequently larger in size than impact blood spatter.

Arterial: When an artery is breached, blood is projected in varying amounts.

Expirated: As a result of trauma, blood will often accumulate in the lungs, sinuses and airway passages; may appear diluted, may have visible air bubbles within the stains-vacuoles.

- **Misting:** Is not frequently seen, but when it is observed it is indicative of gunshot.
- **Satellite spatter/stain**: Small spatter produced around the parent stain as a result of striking a rough target surface.
- **Drip Patterns**: Will result from blood drops falling into previously deposited wet bloodstains or small pools of blood.
- Several factors influence the appearance of satellite spatter, including:
  - Blood drop volume
  - Freshness of the blood
  - Surface texture
  - Distance of the vertical target from the impact site

- **Splashed Bloodstain Pattern**: Will be produced when a quantity of blood in excess of 1.0 Ml, is subjected to minor force or is allowed to fall freely to a surface. They usually have a large central area with peripheral spatters appearing as elongated bloodstains.
- **Ricochet**: May occur as a result of the deflection from one surface to another of large volumes of blood after impact.
- **Projected Bloodstain Pattern**: Is produced when blood is projected or released as the result of force exceeding that of gravity.
- The type of arterial pattern observed will change depending on:
    - Severity of the injury
    - Size and location of the artery
    - Whether the injury is covered by clothing
    - The position of the victim when the injury was inflicted
- **Transfer Pattern**: When an object wet with blood comes into contact with an object or secondary surface.
- The determination of whether the bloodstains on garments are the results of spatter or transfer is not always easy and often requires experimentation and microscopic examination of the garments.
- The drying time of blood is a function of its volume, the nature of the target surface texture, and the environmental conditions.
- **Skeletonized Bloodstain**: When the center of a dried bloodstain flakes away and leaves a visible outer rim; or when the central area of a partially dried bloodstain is altered by contact or a wiping motion that leaves the periphery intact.
- **Clotting Process**: Red to reddish brown and eventually to black. Normal clotting time ranges from 3 to 15 minutes in healthy individuals. Progressively forms a jellylike mass, it retracts and forces the serum out of and away from the progressively stabilizing clot.
- Bloodstains covered with soot may be entirely missed at the scene of a homicide that preceded a fire.
- Heat and fire may also cause existing bloodstains to fade, darken, or be completely destroyed.
- **Void Areas**: Or patterns are absences of bloodstains in otherwise continuous patterns of staining. Helps establish sequencing and identify alterations within a crime scene.
- **Bloodstain on Clothing**: Generally two questions arise with bloodstained garments:
    - Whose Blood is on the garment?
    - How was the blood deposited onto the garment?
- The deposition of blood onto garments falls into one or both of the following categories:
    - Passive Bloodstaining: Including transfer, flow patterns, saturation stains, and stains resulting from dripping blood.

  - Active Bloodstaining: Including impact spatter, arterial spurts, expirated bloodstains, castoff, etc.
- To facilitate the examination of clothing by a bloodstain analyst, the following steps should be taken:
  - Establish how the garments were collected, documented, prior to their examination.
  - Document the garments with the victim or suspect is still wearing them when possible
  - Allow the bloodstain analyst an opportunity to examine the stains before their removal for DNA analysis.
  - Take photographs before cuttings are removed
  - Obtain a history of where the garment has been and how it has been handled.
- When documenting bloodstain patterns, attention should be given to the following points:
  - Accurately document the size, shape, and distribution of the individual stains and overall patterns
  - Include measuring devices within the photographs
  - Use more than one mechanism for documentation (photos, notes, video, diagram)
  - Collect, when possible, articles of evidence that may contain significant or questionable patterns
  - Utilize overall, mid-range, and close-up macrophotography when documenting bloodstain patterns.
  - Complete the documentation in such a manner that a 3rd party could use your notes, photos, diagrams, etc.
- It is possible to beat, stab, or shoot someone without being spattered with blood. The absence of bloodstaining on an active participant in a bloodshed event has several explanations:
  - The directionality of the blows with a blunt object or thrusts with a knife may direct spatters of blood away from the assailant.
  - If the site of the injury is covered with clothing or other material the spatter will be greatly reduced or absent.
  - The assailant may have cleaned up or changed clothing prior to being apprehended.
  - The assailant may have worn protective outerwear
  - The assailant may have removed his clothing prior to committing the assault
  - The amount of blood present at a scene (bloodbath) may be from active bleeding from victim after assailant left the scene.

Chapter 4 Review Questions:

1. **What significant physical properties of blood determine the shape of a blood drop in flight?** Blood, whether a single drop or large volume, is held together by strong cohesive molecular forces that produce a surface tension within each drop and on the external surface. Surface tension is defined as the force that pulls the surface molecules of a liquid toward its interior, decreasing the surface area and causing the liquid to resist penetration. The surface tension of blood is slightly less than that of water. To create spatter of blood, an external force must overcome the surface tension of the blood. The shape of a blood drop in air is directly related to the molecular cohesive forces acting upon the surface of the drop. These forces cause the drop to assume the configuration of a spheroid.

2. **What is the most important factor governing the degree of distortion and amount of spatter created when a blood drop strikes a surface?** Although a single drop of blood falling through air is affected by the forces of gravity and air resistance, these forces do not overcome the surface tension of the blood. No matter how far a drop of blood falls, it will not break into smaller droplets or spatters unless something disrupts the surface tension. One factor in breaking the surface tension of a blood drop is the physical nature of the target surface the drop strikes. A hard, smooth, nonporous surface will create little if any spatter, in contrast to a surface with a rough texture such as wood or concrete that can create a significant amount of spatter. Rough surfaces have protuberances that rupture, the surface tension of the blood drop and produce spatter and irregular shaped parent stains with spiny or serrated edges.

3. **What factors influence the stain diameter produced by a free-falling drop?** The volume of a typical or average drop of blood has been reported to be about 0.05 mL, with an average diameter of about 4.5 mm (while in air). These reported measurements can vary as a function of the surface from which the blood has fallen and the rate at which the blood accumulates.

4. **How are the physical characteristics of spatter utilized to determine their angle of impact?** The geometry of individual bloodstains will generally allow the analyst to determine their direction of flight prior to impacting an object. This is done by examining the edge characteristics of individual stains. The narrow end of an elongated bloodstain usually points in the direction of travel. After the directionality of several bloodstains has been determined, an area or point of convergence may be established by simply drawing straight lines through the long axes of the bloodstains. The area where these lines converge represents the relative location of the blood source in a two dimensional perspective on the x and y axes. This area of convergence will be an area, not an exact point. The area of origin or the location of the blood source is in a three dimensional perspective can also be determined. By establishing the impact angles of representative bloodstains and projecting their trajectories back to a common axis extended at 90 degree up from the two dimensional area of convergence along the z axis, an approximate location of where the blood source was when it was impacted may be established.

5. **Compare the size ranges of the spatters in the following scenarios: (1) spatter associated with a beating, (2) spatter associated with a gunshot, and (3) expirated blood**.

    a. Beating: generally exhibit a size range of 1-3 mm in diameter. The spatter may be smaller or larger than this general range, depending on the force of the impact and the quantity of available exposed blood.
    b. Gunshot: may produce minute spatter of blood less than .1 mm in diameter that are often referred to by analysts as mist-like dispersions. Misting is not seen with any other incidents except high power tool accidents or explosions. Size of spatter depends on quantity of blood, caliber of weapon, location and number of shots, impeding factors like hair and clothes. Back spatter will occur at the entrance point of bullet, hits gun and shooter possibly. Forward spatter comes from the exit wounds.
    c. Expirated blood: will generally have bubbles in the blood from being coughed up. Same size and distribution as impact spatter and gunshot wounds. Cannot be present unless you see blood on the face, nose or mouth of victim, or an injury to the chest/airway. Appears diluted. When the air bubbles pop the voids appear as vacuoles. Bubbles, vacuoles and dilution will not always be present however.

6. **What other mechanisms can create spatters in the same size range as impact spatter encountered in beating, stabbing, and gunshot events?** Impact spatter of this type can also be produced in cases involving explosions, power tools, high speed machinery injuries, and occasionally high speed automobile collisions.

7. **What variables can affect the size, quantity, and distribution of spatters created by an impact mechanism such as beatings and shootings?** Depends on the quantity of blood, caliber of weapon, location and number of shots, impeding factors like hair and clothing. What part of the body they are being beat on.

8. **Discuss the techniques employed for determining the area of convergence and origin of bloodstain pattern**. After the directionality of several bloodstains has been determined, an area or point of convergence may be established by simply drawing straight lines through the long axes of the bloodstains. The area where these lines converge represents the relative location of the blood source in a two dimensional perspective on the x and y axes. This area of convergence will be an area, not an exact point. The area of origin or the location of the blood source is in a three dimensional perspective can also be determined. By establishing the impact angles of representative bloodstains and projecting their trajectories back to a common axis extended at 90 degree up from the two dimensional area of convergence along the z axis, an approximate location of where the blood source was when it was impacted may be established.

9. **Name two types of bloodstain patterns that require confirmation by autopsy findings**:
    a. Arterial Bloodstain patterns: When an artery is breached, blood is projected from it in varying amounts. The size of arterial bloodstains varies from very large gushing or spurting patterns to very small spray types of patterns. The type of arterial pattern observed is a function of the severity of the injury to the artery, the size and location of the artery, whether the injury is covered by clothing, and the position of the victim when the injury was inflicted. Obviously, arterial bloodstaining is accompanied by demonstrable arterial damage. The bloodstain pattern analyst should verity his/her hypotheses about an arterial bloodstain pattern by reviewing the autopsy report or speaking directly with the forensic pathologist who conducted the autopsy.
    b. Expirated Bloodstain patterns:
10. **Explain why an assailant might not have any bloodstains on his or her person or clothing after participating in a beating death**. It is possible to beat, stab, or shoot someone without being spattered with blood, and exceptions to this rule are few. There are many reasons why this could happen.
    a. The directionality of the blows with a blunt object or thrusts with a knife may direct spatter or blood away from the assailant.
    b. If the site of the injury is covered with clothing or other material during the assault, the amount of spatter may be greatly reduced or absent.
    c. The assailant may have cleaned up or changed clothing prior to being apprehended.
    d. The assailant may have worn protective outerwear.
    e. The amount of blood present at a scene described as “covered in blood” or a “bloodbath” may be primarily due to the active bleeding from a victim who is still alive or from the draining of blood from wounds of a deceased individual that occurred after the assailant left the scene.
    f. Individuals have been known to confess to crimes that they, in fact, did not commit.

11. **Explain the mechanism of castoff bloodstain patterns**. During a beating with a blunt object, blood does not immediately accumulate at the impact site with the first blow. As a result, no blood is available to be spattered or cast off. Spatter and castoff patterns are created with subsequent blows to the same general area where a wound has occurred and blood has accumulated. Blood will adhere in varying quantities to the object that produced the injuries. A centrifugal force is generated as an assailant swings the bloodied object. If the centrifugal force generated by swinging the weapon is great enough to overcome the adhesive force that holds the blood to the object, blood will be flung from the object and form a castoff bloodstain pattern. The blood that is flung (castoff) will strike objects and surfaces, such as adjacent walls and ceilings in the vicinity, at the same angle from which it is flung or cast. The size, distribution, and quantity of these castoff bloodstains vary. Castoff bloodstain patterns may appear linear in distribution, and the individual stains are frequently larger in size than impact blood spatter.

12. **What are the features of progressive drying and clotting of blood?**

a. Drying: The drying time of blood is a function of its volume, the nature of the target surface texture, and the environmental conditions. Drying time is accelerated by increased temperature, low humidity, and increased airflow. Initially, the outer rim or perimeter of the bloodstain will show evidence of drying, which then proceeds towards the central portion of the stained area. When the center of a dried bloodstain flakes away and leaves a visible outer rim, the result is referred to as a skeletonized bloodstain. As dried bloodstains age, they tend to progress through a series of color changes from red to reddish brown and eventually to black. The estimation of the age of blood based on color is difficult because environmental conditions and the presence of bacteria and other microorganisms affect the sequence and duration of color changes.
b. Clotting: is also initiated when blood exits the body and is exposed to a foreign surface. The appearance and extent of clotted blood at a scene may provide an indication of the amount of time elapsed since the injury occurred. Normal clotting time of blood that has been exited the body ranges from 3-15 minutes in healthy individuals. As a clot progressively forms a jellylike mass, it retracts and forces the serum out of and away from the progressively stabilizing clot. Clots of blood may show drag patterns that indicate that additional activity, such as movement or further injury, occurred after a significant interval had elapsed from the initial bloodshed.

13. **How can bloodstains be physically altered at crime scenes?** The drying process will alter the stain. Heat, moisture such as snow and rain can dilute the stain making it hard to see. People can try and clean up a scene so you will see wipes/swipes that should not be there. Items can be dragged through the blood or walked through. Heat from a fire or ash can hide it or darken it making it more difficult to recognize. Flies walking through it will leave transfer stains where they land next. This can look like high impact stains due to the size of the flies' feet. Transfer patterns also will occur where an object covered in blood will be placed on something and the blood will transfer to that location. When the item is picked up again this could smear the pattern or distort it.

14. **What important information can be derived from the examination of bloodstain patterns?** You can tell if someone was in the room by void patterns. You can tell if someone has been moved. You can tell if someone walked through the blood. You can tell if someone was close to the gun when it was shot by back spatter. You can sequence the blood events and tell what potentially happened.

15. **What methods are commonly used to document bloodstain evidence?**
    a. **Stringing**
    b. Photography
    c. Sketching
    d. Angle of impact calculations
    e. Angle of origin calculations

Chapter 5: Death Investigation

- Death investigation systems are not exclusively forensic, but rather public service functions.
- Office of the Coroner has existed in England since before the 10th century.
- Massachusetts was the first state to license nurses, physicians, and lawyers.
- 1877 – Massachusetts legislature passed a stature that replace coroners with medical examiners and require medical examiners to be licensed to practice medicine.
- WWI – larger cities began adopting the medical examiner system due to local scandals that were arising from deaths that were improperly investigated by coroners.
- The Commission on Uniform State Laws was created to develop model laws that could be adopted by every state and thus allow more efficient commerce. One of those statutes was the Medical Examiners Act.
- The creation of the District of Columbia led to establishment of the first federal governmental coroner. In 1970 coroner system was abolished and medical examiner's office took over.
- 1990 Armed Forces Medical Examiner's Office was created. It serves the military and is administered from the U.S. Armed Forces Institute of Pathology.
- **Forensic Pathologist**: Physicians specializing in pathology (the diagnosis of disease) and who then subspecialize in the borderline area between law and medicine that emphasizes the determination of the cause of death.
- Pathologists began to appear in hospitals in Europe and US in the mid-19th century.
- **Forensic Pathology**: Was recognized by the American Board of Pathologists after the end of WWII. In most large cities of US the medical examiner is required to be a forensic pathologist. They also handle autopsies for coroners in rural areas.
- The goal of death investigation is to determine:
    - The cause
    - Manner
    - Mechanism
    - Time of death
- **Cause of Death**: Is the disease or injury that initiated the lethal chain of events that led to death.
- **Mechanism of Death**: Is a biochemical or physiologic abnormality produced by the cause of death that is incompatible with life.
- **Manner of Death**: The fashion in which the cause of death came to be: Natural, Accidental, Suicidal, Homicide (NASH), you could also consider undetermined or unclassified.
- When a person dies, changes in the body occur that can be used to estimate the time of death. They are:
    - Rigor mortis

  - Livor mortis
  - Algor mortis
- **Rigor Mortis**: Stiffening of the muscles following death; this is a chemical reaction that occurs when the glycogen normally found in muscles is depleted. Glycogen provides energy for the contraction of muscles, depletes slowly after death: rigor is seen about 4 hrs after death (sooner if glycogen was used up from exercise prior to death; instant rigor mortis i.e. war deaths.) Rigor disappears during the period from 24-36 hrs.
- **Livor Mortis**: Discoloration of the body that occurs from settling of red blood cells after the blood stops circulating. Lividity can be visible minutes after death....will fix about 12 hrs after death. Lividity slowly disappears with decomposition at approximately 36 hrs.
- **Algor Mortis**: Cooling of the body after death, assuming the ambient temperature is lower than the body temperature. General rule 1.5° temperature drop per hour for the first 8 hours.
- A medical history is generally the starting point of any investigation.
- **Sudden Death**: A death that occurs within a few hours of the onset of symptoms or death without any symptoms.
- **Incised Wounds**: Injury produced by a sharp instrument and characterized by lack of surface abrasion and absence of bridging vessels, nerves, and smooth margins.
- **Autopsy**: Means to look at oneself.
- **Necropsy**: Looking at the dead.
- In the U.S. postmortem dissection is mandatory if a death is properly within the jurisdiction of the coroner or medical examiner, and the cause of death is not determinable without dissection.
- **Inframammary Incision**: Beginning at each shoulder, extending to the midline of the body in the lower chest, and extended to the top of the pubic bone. It has been replaced by the "T-shaped" incision because it facilitates examination of the tongue and neck.
- **Fixation**: Is a chemical process that causes proteins to harden; it preserves the tissue and prevents further decomposition.
- Toxicological sampling:
  - Blood is taken from venous blood; more reliable than heart or aorta. Some drugs redistribute in postmortem period. Drugs will show up better in venous blood. Alcohol is more commonly found in blood.
  - Urine; opiates, diazepines and cocaine show up in urine.
  - Bile; from gall bladder.
- **Traumatic Deaths**: Mechanical, thermal, chemical or electrical. A mechanistic classification termed asphyxia death overlaps the other causes. Asphyxial death is caused by interference with oxygenation of the brain. This asphyxia can occur from mechanical causes (strangulation), chemical causes (cyanide poisoning), and electrical causes (low-voltage electrocution).
- **Mechanical Trauma**: Occurs when an applied physical force exceeds the tensile strength of the tissue to which the force is applied. There are two categories:

  - **Sharpe Force**: Injury to soft tissue or bone caused by a sharp-edge or pointed weapon or instrument.
  - **Blunt Force**: A non-penetrating injury that results from force applied to the body. Causes death most commonly when the brain has been significantly damaged; blunt force trauma can lacerate the heart or aorta leading to exsanguination.
- It is difficult to precisely determine the size of a sharp object from examination of the characteristics of the wound.
- Death from blunt and sharp trauma arises from multiple mechanisms, but sharp trauma most commonly causes death by exsanguination or bleeding to death. Thus, a major artery or the heart must be damaged to produce death from sharp trauma.
- The extent of injury produced by a firearm projectile increases as the square of the velocity increases (Kinetic Energy = ½ mv^2). M = mass and V = velocity. The cutoff point between high and low velocity is generally noted as 300 meters per second.
- **Lead Snowstorm**: A characteristic pattern of lead deposition that results from high speed bullet impact with tissue.
- High-Speed Projectiles are only seen in wounds inflicted by high-powered hunting rifles and military rifles.
- **Penetrating Gunshot Wound**: Has an entrance wound and no exit wound.
- **Perforating Gunshot Wound**: Has an entrance wound and an exit wound. Usually no projectile will be recovered with this type of wound.
- **Distance Determination**: The distance from the shooter to the victim. Gunshot wounds can assist in this estimation.
- **Contact/Near Contact Wounds**: The skin will show variable amounts of laceration because the gas blown into the wound tears the skin apart. On heads there will be tearing characteristics of the scalp and the reflection of gasses by the skull. This will produce large lacerations that are characteristics of head contact wounds.
- **Carboxymyoglobin/Carboxyhemoglobin**: Carbon monoxide reacts with the hemoglobin and myoglobin in the wound to produce these compounds. They are bright red, compared to the dull red color of normal hemoglobin and myoglobin.
- **Stippling/Tattooing**: Unburned powder that penetrates the skin around the defect produced by the bullet. These wounds are referred to as intermediate range gunshot wounds. Skin to muzzle distance 0.5cm to 1 meter.
- Powder will penetrate the skin at the speed of 100 meters per second.
- **Intermediate Range Gunshot Wound**: Produces stippling/tattooing.
- **Distant Gunshot Wounds**: Lack smoke and powder effects. The range is indeterminate because clothing and other objects can block the effects of gas and powder. There is a lack of smoke, soot and stippling. A typical distant wound has a circular skin defect and a rim of abraded (scraped) skin around the edges. The diameter of the skin defect is some indication of the diameter of the bullet, but the estimate is not reliable because skin is elastic so the size of the entrance wound is variable, and defects on the skin will be smaller.
- Determining the caliber of the weapon from a contact wound is not possible, as the wound bears little relationship to caliber due to the tearing of the skin.

- The error rate of emergency room physicians without forensic training in determining directionality of suicidal contact gunshot wounds to the head is almost 100%.
- **Shored Exit Wounds**: When an exit wound is supported/shored by tight fitting clothing, the exit wound looks remarkably like entrance wounds. Often the rim of abrasion is wider than is typically seen in an entrance wound. This may help in differentiating the two types of wounds.
- The destruction produced by a bullet is proportional to the kinetic energy (KE) loss of the bullet in the body of a person.
- Increasing the speed and decreasing the diameter of bullets for military weapons have enhanced their effectiveness.
- **Hollow Point Bullets**: Bullets that are designed to enlarge their diameter during passage through tissue. They are cast with defects in the noses.
- When a bullet enters a person, it is traveling much faster than the velocity at which tissue tear, so it pushes tissue out of its way. This stretches tissue beyond its breaking point, but it does not break. It only breaks at a much slower speed than the bullet travels.
- **Perfusion of the Brain**: When there is loss of blood pressure. The brain will function for 10 to 15 seconds after it loses perfusion. This is seen when the heart is hit with a bullet and blood drains out no longer circulating through the body.
- Most blunt force injuries in our society are from transportation collisions, usually motor vehicle injuries, ruled as accidents.
- **Contusion**: An accumulation of blood in the tissues outside the blood vessels. Caused by blunt force impact that distorts the tissue sufficiently to break small blood vessels that then leak blood.
- **Hematoma**: A blood tumor (hema = blood; toma = tumor). They are contusions with more blood. Example would be a blunt impact to the head that produces a hematoma "goose egg."
- **Chemical Trauma**: Death from trauma include deaths that result from the use of drugs and poisons.
    - Alcohol
    - Carbon Monoxide
    - Cyanide
- **Alcohol**: 50% of traumatic deaths are related to the abuse of the drug "ethanol" (ethyl alcohol). Alcohol can also kill directly. It is a central nervous system depressant; it slows the reaction and communications from brain and spinal cord neurons. At a level around 0.30g% the person will be in a deep coma, cannot be roused, and will breathe slowly enough to eventually die. A lack of oxygen causes death resulting from alcohol overdose.
- **Carbon Monoxide**: Chemical that produces death. It is produced in minute amounts by the body through a reaction that produces Porphyrin (a component of hemoglobin). CO kills by asphyxiation. It cuts off the oxygen to the brain because it binds to hemoglobin 300 times more strongly than oxygen does. Blood levels of CO as low as 20% may prove fatal.
- **Cyanide**: Is similar to CO in that it interferes with the oxygenation of the brain, acting primarily on the enzymes in the mitochondria of the brain. Cyanide consists of carbon and

nitrogen. It smells like almonds and can be detected in concentrations as little as 1 part per million. 50% of the population cannot smell it.

- **Dr. Bernard Spilsbury (1877-1947 England)**: Forensic pathologist in England. Wife buried in basement no head/feet/hands. Identified by scar and found scopolamine in tissue. Husband found guilty because of this. Spilsbury committed suicide using CO.
- **Thermal Trauma**: Exposure to excessive heat or cold, may cause death.
  - **Hypothermia**: Excessive cold
  - **Hyperthermia**: Excessive heat
- **Homeostasis:** The ability to maintain a constant body temperature. This ability declines as people age.
- **Thermal burns**: Are localized wounds caused by hyperthermia. 150 Fahrenheit will produce them upon direct contact with an object for a few minutes. Death will occur under a wide range of circumstances. Exposure to hot liquids, burns from flaming hydrocarbons.
- Deaths from burns are usually delayed and arise from complications after medical treatment. The mechanism of death is generally multiple organ failure.
- **Electrical Trauma**: The passage of electricity through a person. May cause death by a number of different mechanism.
  - Ventricular fibrillation
  - Tetany
  - Poration
- **Ventricular Fibrillation**: If a circuit of alternating current (AC) at low voltages (below 1000 volts) crosses the heart, the heart will experience ventricular fibrillation. This is a quivering that leads to non-resuscitability within minutes (300 quivers per minute). It is less likely to happen with high voltage because the amount of current becomes defibrillator.
- **Tetany**: High voltage current forces the heart into this state, a sustained contraction that is broken when the circuit is broken. The heart will generally start again with a normal rhythm.
- **Poration**: The flow of current through tissues creates holes in the membranes of cells. This causes the devastating loss of limbs of people exposed to high voltage.
- **Asphyxias**:
  - Asphyxia
  - Manual Strangulation
  - Strangulation by Ligature
- **Asphyxia**: The interruption of oxygenation of the brain. Drowning is asphyxiation by immersion in water or other liquid. Lungs of the victim will show signs of hyperinflation as a result of the spasm of the muscles protecting the alveoli. Finding diatoms in the bone marrow will confirm drowning.
- **Manual Strangulation**: (with the hands). Constricts the airway by compressing the neck. The Hyoid Bone potentially can be fractured but not as common as people think. It is usually only seen in elderly women who have osteoporosis which makes the fracture happen easier. If it is fractured and hemorrhage is absent, the fracture occurred after death. The more common finding is a fracture of the **cornu of the thyroid cartilage**. The

cornu is located in the larynx or voice box and rests against the front of the cervical spine, and hemorrhage into the muscles of the neck which are called strap muscles.

- **Ligature Strangulation**: Generally, the only findings are asphyxia and the presence of a furrow in the neck.

Chapter 5 Review Questions:

1. The coroner is unique in English law because he is an **Inquisitional** judge.

2. Forensic pathologists are employed primarily by **Counties**.

3. **What other forensic science disciplines are included in forensic pathology training**? Forensic Pathologists.

4. **What is the first determination that must be made when investigating a death?** The goal of death investigation is to determine the cause, manner, mechanism, and, to the extent possible, time of death.

5. **The jurisdiction of the coroner or medical examiner to investigate deaths generally can be categorized as including deaths of what type**?

6. Attending the scene of death by the forensic pathologist is most helpful in **Homicides/Unattended**.

7. **What is the medical term for stiffening of the body due to postmortem depletion of glycogen?** Rigor Mortis.

8. **Drug screens are usually performed on what specimen taken during an autopsy**? Taken from blood found in the veins. Also, blood and urine are routinely used to determine the presence of common drugs of abuse.

9. **Dissection of the legs is done if what condition is found during the autopsy?**
    a. It is done if blood clots are found in the lung because clots often originate in the legs.
    b. In the cases where death occurs in police custody, extensive dissections are required to rule out torture. This includes the examination and dissection of the soles of the feet, arms, and legs to look for evidence of subtle blunt trauma.

10. **Microscopic sections are fixed in a solution of what chemical?** Formaldehyde. Used to fix them and preserve them for further study.

11. **Describe four causes of traumatic death**:
    a. Mechanical: Occurs when an applied physical force exceeds the tensile strength of the tissue to which the force is applied. Divided into two other categories

a. Sharp Force: Caused by sharp implements, such as knives, swords, and axes. The force needed to exceed the tensile strength is significantly less than the force required with a blunt object. Produces incised wounds. Usually will cause death by exsanguination.
b. Blunt Force: Causes death most commonly when the brain has been significantly damaged. Has been subdivided into two smaller categories
    1. Non-Firearm
    2. Firearm

b. Thermal: Exposure to excessive heat or cold.
c. Chemical: Include deaths that result from the use of drugs and poisons.
d. Electrical: The passage of electricity through a person may produce death by a number of different mechanisms. This includes:
    a. Ventricular Fibrillation
    b. Tetany
    c. Poration

12. **Which causes of traumatic death may be produced by asphyxia**? Drowning, manual strangulation, CO poisoning.

13. Describe the four manners of death.
a. Natural: Caused by disease, without the intervention of trauma.
b. Accidental: Due to trauma occurring from acts no reasonable person would have felt had a high probability of producing bodily injury or death.
c. Homicidal: Done by someone else
d. Suicidal: Done by the victim

14. **How are gunshot wounds of entrance classified**? Blunt force trauma
a. Penetrating Gunshot Wound: has an entrance wound and no exit wound.
b. Perforating Gunshot Wound: has an entrance wound and an exit wound.

15. **Which drug of abuse is most often encountered in the practice of forensic pathology**? Alcohol

16. **What three features differentiate lacerations from cuts or incised wounds**?
a. Incised wounds: Injury produced by a sharp instrument and characterized by a lack of surface abrasion and absence of bridging vessels, nerves, and smooth margins.
b. Lacerations: Injury produced by blunt instruments; characterized by surface abrasion, bridging vessels, and nerves with irregular margins..

17. **Differentiate between a perforating and a penetrating gunshot wound**.
a. Penetrating Gunshot Wound: has an entrance wound and no exit wound.
b. Perforating Gunshot Wound: has an entrance wound and an exit wound.

18. **Describe the unicellular organisms that may prove helpful in diagnosing drowning**. They are called diatoms, and they are found in most fresh and salt waters in the world. These organisms have silica in their cell walls; thus, they resist degradation by acids. During the late stages of drowning, aspirated water containing diatoms is circulated by the still-beating heart into all the organs. Diatoms are not ordinarily found in bone marrow. So, cut out bone marrow, dissolve in acid and if you see the diatoms they person drown. Works best for bodies that are severely decomposed.

19. **Describe the common finding in manual strangulation**. Constricts the airway by compression the neck. Possible hyoid bone fracture (not seen much). This is usually seen in older women who have osteoporosis. Hemorrhage around the fracture site of the bone will tell you if it happened during/after death. You will see fracture of the cornu of the thyroid cartilage as well as hemorrhage in the muscles of the neck (strap muscles).

20. **Describe the common findings in ligature strangulation**. Does not involve fracture of the hyoid, fracture of the cornu of thyroid cartilage, or hemorrhage into the muscles. Generally the only findings are asphyxia and the presence of a furrow in the neck.

Chapter 6: Forensic Anthropology

- **Forensic Anthropology:** Application of the theory and methods of anthropology to forensic problems. Most specialize in physical anthropology, the study of human biological function and variation, particularly skeletal biology. They help in the investigation of death and injury for criminal or civil legal purposes.
- The American Board of Forensic Anthropology currently certifies practitioners at the doctoral level only.
- Forensic Anthropology has expanded its specialists to four areas:
    - Forensic Taphonomy
    - Forensic Archaeology
    - Modeling soft tissue form based on underlying skeletal form (facial approximation)
    - Biomechanical interpretation of sharp and blunt force injuries, primarily to bones.
- **Forensic Taphonomy**: Interpretation of primarily outdoor death scenes and postmortem processes.
- **Forensic Archaeology**: Recovery of scattered or buried remains.
- Examination of human remains by the forensic anthropologist focuses on three tasks:
    - Identifying the victim or at least providing biological profile
    - **Taphonomic Assessment**: Reconstructing period based on the condition of the remains and the recovery context
    - Providing data regarding the death event, including evidence of trauma occurring at the time of death, the perimortem period.
- **Biological Profile**: Determining the age, sex, stature, ancestry, anomalies, pathology, and/or individual features from bones.
- **Krogman, W.M.**: (1939) Published in the FBI Bulletin, a pivotal article on examining skeletal remains, marking the commencement of the modern period for this discipline.
- Beginning at WWII and Korean Wars anthropologists became involved in the identification of war dead.
- 1972 the Physical Anthropology Section of the American Academy of Forensic Sciences was established.
- 1977 establishment of the American Board of Forensic Anthropology (ABFA).
- Because bones and teeth survive over time, many physical anthropologists specialize in human Osteology and Odontology.
- 206 bones in the adult human (approximately).
- 405 bones in children and infants. The number is much higher because some of the bone **Ossification Centers** have not yet fused together. Newborn infants can have as many as 405 and bone growth centers.
- Postmortem alterations must be differentiated from the antemortem condition of the body in order to establish time since death, reconstruct the place of death, interpret data regarding cause of death, and sometimes to properly identify the remains.
- Archaeological techniques are used to map a scatter pattern or to document the relationship between body parts and other evidence at the scene.
- Photograph and sketch scene before work begins. Area should be examined for:

  - Insects that may be associated with the body.
  - Any living plants directly associated with the body and indicative of post mortem intervals.
  - Metal artifacts
  - Sediment samples are taken from the perimeter area and the grave matrix.
- The crime scene is destroyed as the body and evidence are removed.
- After the hands, feet, and head are exposed and photographed, it is a good idea to bag them to prevent bone loss, teeth, and finger nails being lost.
- A forensic anthropologist can identify non-modern cases, usually by the appearance of the body and the grave as well as the items found in the grave or coffin fragments.
- **Taphonomic Context**: The immediate environment and surrounds where a body is found. Documenting the condition of the body is critical, as it can provide clues about how long it has been there and what has happened to it since death. This is the Taphonomic assessment.
- Taphonomic data, including input from other experts, can be used to:
  - Estimate postmortem interval
  - Reconstruct postmortem event sequences (such as if the body was moved)
  - Identify potential wounded areas of the body (insect activity)
- It is important to note environmental characteristics that affect how much heat has been reaching the body as well as the amount of moisture or precipitation.
- Any coverings on the body may affect heat and moisture, as will nearby water or the depth of a burial.
- Finding out about recent patterns of temperature or precipitation is necessary to estimate the postmortem interval.
- When washing / boiling the bones, don't over process as this will destroy bone integrity.
- The skeleton is formed by the development and growth of ossification centers, which gradually replace cartilage. By the time a fetus is fully developed into a newborn, approximately 405 ossification centers are present. When an individual reaches adulthood, that number is about 206 fully formed bones.
- Humans have two sets of teeth:
  - Deciduous dentition: child, 20 teeth
  - Permanent dentition: 32 teeth
- **"Shoveling:"** A trait commonly seen with Asian or Native Americans where the anterior teeth are slightly thicker (ridged) around the margins of each tooth on the tongue side.
- **Bone Density**: Reaches its peak in the 20's and stays fairly high in the 30's, but begins to decline in the 40's.
- **Pubic Symphysis**: One of the most reliable indicators of adult age. It is the area on the pelvis where the right and left pelvis halves join in the front of the body. With age, these surfaces change from billowed to more flattened and rimmed. The changes have been divided into age and sex associated stages.
- **Cranial Suture**: Closures may be appropriately used as one of several measures for identification of age in bones. Older people have more fuses.

- **Sexual Dimorphism**: Term used for the differences in size and shape between the sexes.
- **Gender**: The psychological and sociocultural attribution of sex.
- **Biological Sex**: Which is based on genetic and hormonal differences. This is what is used to identify bones. They will not state gender.
- **Race:** Definitions of race are socially constructed typologies, with little biological basis. There is no empiric biological base for the race categories.
- **Stature**:
  - Not a fixed trait. People shrink
  - Measurements frequently done wrong. Dramatic errors.
- When remains are incomplete, estimates of stature are done by extrapolating from the lengths of individual long bones, or combinations of long bones.
- **Allometry**: The ability to estimate stature from long bone lengths depends on the presence of patterned and proportional relationships between the size of body parts. Not systematic and differ from population to population.
- Positive Identification of a body requires one of the following:
  - DNA analysis
  - Fingerprints
  - Dental records
  - X-rays
  - Uniquely identifiable medical apparatus such as a joint
- **Facial Approximations**: Recreating the soft tissue appearance based on the shape of the bones of the face. This process has significant limits and are not a means of positive identification.
- **NamUs**: National Missing and Unidentified Persons System. Used for reporting and linking data about unidentified remains to data about missing persons.
- **Congenital Anomaly**: Example would be cleft palate, extra lumbar vertebra etc.
- Markers of occupational stress: is neither straightforward, nor, in most cases, possible for most forensic cases.
- **Antemortem Trauma**: Healed or healing prior to death
- **Perimortem Trauma**: Occurring at or around the time of death
- **Callus**: The formation of a bony scar at the site of a fractured bone.
- Blunt Force or Sharp Force Damage to bones produces impact marks or fractures and can fragment bones.
- **Plastic Deformation**: Change in shape that results from serious injury, such as when bone is bent beyond its elastic capability to return to the original shape. Warping of the fragments.
- It is recommended that the basic forensic anthropology report include five components:
  - Chain of custody
  - Taphonomic assessment
  - Biological profile (age, sex, ancestry, stature, anomalies, pathology)
  - Identification characteristics and interpretations
  - Description of trauma

Chapter 6 Review Questions:

1. **What role does the forensic anthropologist play in a medicolegal death investigation? Differentiate the role of forensic anthropologist from those of the forensic pathologist and the medical examiner or coroner**. The application of theory and methods of anthropology to forensic problems. They study the human biological function and variations, particularly skeletal biology. They help in the investigation of death and injury for criminal or civil legal purposes. They understand the forms and variations of the human skeleton in individuals and populations which complements the forensic pathologist's emphasis on soft tissue. They only deal with the bones and what happened to them to help identify people. They do not look at the medical aspects as to what caused death.

2. **Recovery of human remains sometimes requires the skills of a forensic archaeologist. Name some of those skills and describe the situations in which those skills are likely to be applied**. Their techniques are used to map a scatter pattern or to document the relationship between body parts and other evidence at the scene. Also their skills in how to dig up a body/scene without damaging or loosing evidence as well as plant material that could assist in the identification. They sift dirt etc. to make sure that nothing is missed.

3. **The condition of the remains should be interpreted with reference to their taphonomic context. What does this mean and how does it affect the tasks of the forensic anthropologist?** Taphonomic context: the immediate environment and surrounding where the body is found. This means that it is important to note environmental characteristics that affect how much heat has been reaching the body, as well as the amount of moisture, as well as nearby water or the depth of a burial. Finding out about recent patterns of temperature or precipitation is necessary to estimate the postmortem interval. By document the condition of the body, you are providing clues about how long it has been there and what has happened to it since death. This is considered the taphonomic assessment. Seeing the body in place is extremely helpful for interpreting postmortem processes. How many bones have been scattered, if they are sun bleached etc. All of this helps to establish the postmortem interval.

4. **When a forensic anthropologist generates a biological profile, what is that likely to include?** An estimation of age, sex, population or ancestry.

5. **What factors may limit the ability of the anthropologist to attribute sex to a set of skeletal remains?** Prior to puberty, although differences exist, they are so small that forensic anthropologists do not attempt to assign sex in those cases. For the most part size is an indicator of sex, but so are muscularity, overall size, and the presence or absence of certain traits. Those traits are larger skulls/foreheads, wider/square jaw line, pelvis areas. Larger joints in males.

6. **A child's long bones provide clues to age. What features of long bones are important in estimating age and why?** In long bones the bony tissue develops from a set of three main

ossification centers; the shaft or diaphysis, and an epiphysis at either end. These three centers will ultimately grow together with the individual reaches full size. The timing of the formation, growth, and ultimate fusion of these and other ossification centers is patterned, depending on age, sex, bone element involved, nutritional and hormonal status, and individual variation. By the time an individual reaches adulthood (generally by his or her mid 20's, that number of ossification centers (originally 405) have decreased to about 206 fully formed bones. So if you have more than 206 bones at a scene, or the long bones haven't fused, you are dealing with an individual younger than their mid 20's.

7. **If bone growth and tooth eruption processes have ended, list several skeletal or dental features that can be used to estimate adult age. In very general terms, how precise are these methods?**
    a. Bone Density: Relies on the thinning of the outer dense bone layer as well as remodeling (changing bone shape), and evidence of fractures. The older you get the more osteons and osteon fragments you will have.
    b. Joint Deterioration: Seen because of wear and made worse by inflammation. It is related to the deterioration of bone density after the age of 40. The resulting condition, osteoarthritis.
    c. Pubic symphysis: area on the pelvis where the left and right pelvis halves join in the front of the body. With age the surface changes from billowed to more flattened and rimmed. The changes have been divided into age and sex associated stages.
    d. Changes to the end of the fourth rib nearest the breastbone or sternum. With age the bones of the braincase or cranium tend to fuse together along the suture connection between them. Generally older people have more fusion, but the range of variation is great for older individuals and is not precise.
    e. Wear and tooth loss. This is depended on dietary practices, dental hygiene, and genetic background. This is not very reliable.

8. **The race concept is socially constructed and socially defined. How does this fact affect judgments the anthropologist might make regarding evidence of ancestry?** There are no absolute physical or genetic reproductive barriers between the major human groups. Race is a socially constructed typology with little biological basis. Regional populations, when viewed as a group, may appear to share more morphological traits with each other, individual group members do not necessarily exhibit all the traits. Decisions about population boundaries are arbitrary, and group membership is ultimately fluid. Population membership based on skeletal characteristics is difficult and often impossible due to the complexity of human mating and migration patterns.

9. **Stature can be estimated based on long bone length. What might limit the precision of these methods?** Stature is not a fixed trait. Adult stature changes (shrinks) from morning until night and over the course of a lifetime. If the body is still essentially complete, the length can be measured, keeping in mind that the loss of muscle support will loosen joints

and lengthen the body somewhat. If the body is skeletal and the joints are no longer held with soft tissue but some long bones are present, stature can be estimated from using formulas that have been developed. People lie about their height as well. Men often exaggerate their height so you would be looking for an estimated height.

When a forensic anthropologist testifies as an expert witness, for which side might he or she testify? Explain your answer, including a discussion of the difference between science and advocacy. They should be neutral and objective regardless of whether they testify for the prosecution or the defense.

Chapter 7: Forensic Entomology

- **Entomology**: The study of insects.
- **Medicolegal Entomology**: Is the study of the insects associated with a body.
- Insects colonize a body almost immediately after death, assuming that the season and environment are appropriate.
- Their rate of development and the species dynamics over time can be used to accurately estimate the minimum time that the person has been dead, from a matter of hours up to a year or more postmortem.
- **Estimating Time of Death**:
    - **Larval Diptera**: Flies, primarily blow flies.
        - **Known passage of time** from when the first egg is laid on the remains until the first adult flies emerge from the puparial cases and leave the body = estimates minimum time since death from a few hours to several weeks.
        - **Successional Colonization**: Based on the predictable successional colonization of the body by a sequence of carrion insects = estimates time of death from a few weeks after death until nothing but dried bones remain.
    - **True Flies (Diptera)**: First insects that are attracted to remains; looking for protein that grows their genitalia so they can reproduce and lay eggs. They are bright green or blue in color. They are **Diurnal** which means that they are active during the day and not at night. They follow a **circadian rhythm**, meaning they are aware of the time of day. Seek out wounds first, orifices second.
    - **First-Instar**: Fly eggs hatch into delicate first stage maggots, which feed on liquid protein.
    - **Second-Instar**: After a brief period of time, primarily dependent on temperature and species, the first-instar larvae will molt into second-instar. Shedding the larval cuticle and mouthparts.
    - **Third-Instar**: The second-instar maggot feeds for a period of time, then molts into the third-instar, again shedding the cuticle and mouthparts of the previous stage. It is a voracious feeder and frequently aggregates in large masses that can generate a tremendous amount of heat. A large amount of tissue can be consumed in a short period of time in this stage. After a period of intense feeding, it enters into a non-feeding or wandering stage and leaves the body, looking for a suitable place in which to pupate where it will not be vulnerable to predation.
        - **The Crop**: A food storage organ which can be seen as a dark oval through the translucent skin of the maggot.
- Maggots may burrow down several centimeters into the soil and may crawl several meters away from the remains until they find a suitable pupation site.
- Pupation stage is just like a caterpillar. The maggot forms a chrysalis and while inside it forms into a fly.
- **Pupate**: Inside the hard outer puparium, the pupa metamorphoses into an adult fly. The fly emerges from the case, spends a few hours drying, and then files away completing the cycle.
- Once a fly is dry and can fly, an adult fly cannot be linked directly back to the remains.

- When estimating time since death using blow fly development there are several factors that must be known:
    - The oldest stage of blow fly associated with the body
    - The species of insect
    - Temperature data
    - Developmental data
- The science of forensic entomology is based on estimating the length of tenure of insects on a body, rather than the actual time of death.
- The sequence of insects that colonize a body depends on the nutritional changes in the body and is greatly impacted by geographic region, habitat, season, meteorological conditions, and microclimate, but the sequence is predictable within those parameters.
- **Things that impact insect colonization**:
    - Geographic region
    - Latitude
    - Exposure
    - Altitude
    - Habitat
    - Urban/Rural location
    - Inside car/building
    - Buried
    - Hanging
    - In water
- Maggot activity will destroy DNA if it is collected and then not frozen. Maggots will continue to feed until frozen or killed.
- Insects can be used to detect drugs/poisons in bodies. Drugs can cause maggots to grow quicker than maggots that did not ingest the drugs. It speeds up their development.
- DNA and maggots
    - Used to determine the type of fly larva
    - Used to identify the person the larva was feeding on
- **Myiasis**: Infestation of living human or other vertebrate animals with dipteran larvae. This happens due to: bed sores, gangrene, poor hygiene.
- **Maggot Debridement Therapy (MDT):** The use of blow fly larvae (maggots) on humans to clean wounds of dead or infected tissue. Was recognized by **Dr. Baer** during WWI.
- **Granulation:** New tissue formation.

Chapter 7 Review Questions:

1. A partially decomposed body is found in the woods. There is no sign of foul play but no obvious indications of the cause of death such as weapons nearby. Describe which forensic practitioners would likely be involved in the death investigation. Which practitioner would you expect to be the final authority in such cases?

2. In the previous scenario, assume that it was discovered that the victim was uninjured and did not have any obvious findings of a disease. However, the toxicology report (discussed in **Chapter 10**) showed fatal levels of a pain reliever in the remaining tissues. What can be determined (and not determined) regarding the cause, manner, and mechanism of death?

3. Suppose that in the above scenario the body was not discovered until the remains were completely skeletonized. Assuming that it is not possible to test bones for drugs, can you think of any way that drugs might be found indirectly?

4. Consider the statement, "The biggest difference between archaeology and crime scene analysis is time." What do you think this means? Do you agree? Use examples in your explanation.

Chapter 8: Identification of Blood and Body Fluids

- Blood is not the only body fluid of forensic interest, and as with blood, there are two challenges with body fluids:
  - Identify a stain as coming from a particular body fluid
  - Use genetic typing methods to link a stain to a person if possible
- Forensic Serology is no longer a commonly recognized discipline due to the advent of DNA typing methods. Studies the following things:
  - Blood
  - Saliva
  - Semen
  - Urine
  - Stains that are degraded or deteriorated
- Identification of a stain as blood is one of the most important preliminary tests performed on physical evidence and one that DNA protocols have not replaced.
- **Blood**: Extracellular fluid, meaning it is found outside of cells in the body. It's a complex mixture of organic and inorganic materials (electrolytes, sodium, proteins etc.). 4.5-6.5 liters in adult depending on size and gender.
- **Plasma**: Non-cellular component of blood. Makes up 55% of blood. Can be subdivided into:
  - **Serum**: Clear/yellow in color. Fluid portion of the blood that does not clot. Carries the following:
    - Electrolytes with sodium and chloride ion being the most concentrated
    - Carbon dioxide
    - Proteins (albumins and globulins)
  - **Fibrinogen**: forms clots
- **Cellular Components of Blood**: Makes up approximately 45% of blood. Three types of cells:
  - **Red Blood Cells** (Erythrocytes): Transport oxygen and bicarbonate. Most numerous. No nucleus. The substance that transports oxygen is hemoglobin.
  - **White Blood Cells** (Leukocytes): Several types. Active in fighting disease. DNA is found in the nucleus of the white blood cells.
  - **Platelets** (Thrombocytes): Needed for clot formation.
- **Confirmatory Test**: Clearly establishes the identification of blood.
- **Presumptive Test**: Is one that, when positive, would lead the forensic examiner to strongly suspect blood is present in the tested sample. It does not confirm blood. It will either produce a visible color reaction or release light. Both rely on the catalytic properties of blood to drive the reaction.
- **Catalytic Color Tests**: Employs the chemical oxidation of a chromogenic substance (One capable of generating a colored species). The oxidizing agent is catalyzed by the presence of hemoglobin-red pigment in blood. A solution of the chromogen is presented to the stain/sample followed by an oxidizing agent (usually hydrogen peroxide). A developed color, characteristic of the chromogen used, constitutes a positive test.

- The catalyst is actually the peroxidase-like activity of the heme group of hemoglobin present in the red blood cells.
- **False Positives**: A positive result from a substance other than blood.
- **False Negative**: A negative result even when blood is present.
- **Misleading results of the color test, can be attributed**:
    - To chemical oxidants (often producing a reaction before application of the peroxide).
    - Plant material (vegetable peroxidases are thermolabile and can be destroyed by heat).
    - Materials of animal origin (to include human) which are not blood but may contain contaminating traces of blood.
    - Oxygen in the air turning the test positive after several minutes.
- **Benzidine (Adler Test)**: Presumptive identification of blood. Carried out in an ethanol/acetic acid solution. Carcinogen that is seldom used anymore. ***Positive = blue***. (O-toluidine was also abandoned because of the carcinogenic findings).
- **Tetramethylbenzidine (TMB) and Hemastix**: TMB is a derivative of benzidine. It uses an acid medium (acetic acid). ***Positive = green***. The Hemastix is a field kit with the end of the stick already impregnated with the solution. Touch the end of the stick to the questioned substance, if there is an immediate color change you have an indication of the presence of blood.
- **Phenolphthalein (Kastle – Meyer Test)**: Simple acid-base indicator. ***Positive = bright pink***. Reduced phenolphthalein in alkaline solution, which is oxidized by peroxide in the presence of hemoglobin in blood. False positives would usually be some other color change.
- ***Luminol***: Luminol and an oxidizer are applied to a bloodstain. The catalytic activity of the heme group then accelerates the oxidation of the luminol. When ***Positive = blue/green***. This is a **presumptive test**. When Luminol reacts with blood, light is produced. These tests are more of a finding tool. They destroy blood.
- **Fluorescein**: Is reduced in alkaline solution over zinc to fluorescin which is then applied to the suspected bloodstain area. Catalytic activity of the hem then accelerates the oxidation by hydrogen peroxide of the fluorescin to fluorescein, which will fluoresce when treated with UV. 450 nm UV spectrum.
- **Chemiluminescence**: The process by which light is emitted as a product of a chemical reaction.
- **Fluorescence**: Occurs when a chemical substance is exposed to a particular wavelength (ALS) of light (usually UV) and light energy is emitted at longer wavelengths. 425 – 485 nm.
- **Confirmatory Tests for Blood**:
    - **Crystal Tests aka microcrystal tests**: These tests target the non-protein heme group of hemoglobin. The two most common tests are:
        - **Teichmann Test**
        - **Takayama Test**
- **Teichmann Test**: Crystal Test. Heat dried blood. Add glacial acetic acid and halide. Forms hematin.

- **Species Origin Determination in Bloodstains**: Not done as much now due to DNA. Tested for the antigen (Ag) and antibody (Ab) to produce a solid.
- **Karl Landseiner (1868-1943 Austrian)**: Figured out blood typing, saving millions of people lives. Awarded the Nobel Prize in medicine because of this.
- **Enzyme Markers**: Discovered between 1971-1980's. Led to a greater ability to discriminate between individuals and evidentiary material and paved the way for the more advanced technologies of DNA analysis.
- **Polymorphism**: The occurrence in a population of two or more genetically determined alternative phenotypes with frequencies greater than could be accounted for by mutation.
- **Phoshoglucomutase (PGM)**: Is a phosphotransferase enzyme that catalyzes the reversible conversion of glucose-1-phosphate to glucose-6-phosphate, an essential reaction in carbohydrate metabolism in the body. In humans the enzyme exists in significant concentrations in blood and semen and in small amounts in vaginal secretions and cervical mucus.
- Avoid exposing biological evidence to prolonged heat and humidity.
- **Seminal Fluid**: Next to blood, it is most often body fluid found at scenes. It is produced by post-pubescent males and ejaculated following sexual stimulation. It contains:
    - Cells
    - Amino acids
    - Sugars
    - Salts
    - Ions
    - Organic/inorganic materials
- Ejaculate volumes of humans rage from 2-6 milliliters and contains between 100-150 million sperm cells per milliliter.
- The following could result in drastically reduced sperm count or absence of sperm:
    - Disease
    - Genetic conditions
    - Chemicals
    - Elective surgery
- Principal cellular component of semen is spermatozoa or sperm cell.
- **Azoospermica**: Semen lacking spermatozoa. This requires that other tests besides identification of the sperm be used.
- **Seminal Acid Phosphatase (SAP):** A phosphatase enzyme found in abundance in seminal fluid. Semen contains a uniquely high level compared with other body fluids and plant tissues. They will remain high until the age of 40 when they gradually begin to decline.
- No correlation exists between the level of SAP and the number of sperm cells present in an ejaculate.
- **Alpha-naphthyl phosphate with Brentamine Fast Blue B:** Used detect semen. Turns Purple if positive.
- False positives:
    - Vaginal secretions
    - Perspiration

  - Feces
  - Urine
  - Combination of these fluids
- Motility if sperms is lost within 3-6 hours of ejaculation
- **Picroindigocarmine (PIC): = (Christmas tree stain)**. Most common staining technique. Developed specifically for sperm cell visualization. Epithelial cells also take up the stain and appear blue-green with red nuclei.
- **Prostate-Specific Antigen (PSA):** Used to detect prostate cancer in men. This antigen has also proven to be useful for identifying a stain as semen. The detection of PSA is proof positive for semen. Concentrations vary from 300-4000 ng per milliliter. Will also be found in:
  - Urine
  - Serum of males
  - Breast milk
  - Sweat glands
- **Saliva:** Slightly alkaline secretion comprised of:
  - Water
  - Mucus
  - Proteins
  - Salts
  - Enzymes
- 1 to 1.5 liters produced each day by human. No test is specific for saliva. Usually they look for alpha-amylase, an enzyme sometimes referred to as **ptyalin**.
- **Amylases**: Are ubiquitous enzymes found in both animals and plants. They are responsible for catalysis of the components of starch, amylose, and amylopectin into smaller, less complex sugars. Beta-Amylases are found in plants, Alpha-Amylases found in animals.
- **Alpha-Amylases**: Found in many body fluids and tissues, but because it is 50 times higher in saliva it is a good marker and used for detection of saliva. Can be detected up to 28 months.
- **Starch-Iodine Test**: In the presence of iodine, starch appears blue. As amylase acts on starch to break it down, the color changes and subsides. This test has several drawbacks:
  - Presence of proteins, particularly albumin and gamma-globulin originate in other body fluids (blood, semen), compete with starch for iodine and produce false positive results.
  - Difficult to use as a locator test for stains on items.
- **Phadebas Reagent – Tube Test**: When starch is cleaved from the dye by amylase, the dye molecule becomes soluble, producing a colored product that can be measured with a spectrophotometer.
- **Press Test**: The reagent can also be dissolved and applied to a large sheet of filter paper which can then be placed on an item. The stains are then mapped by the color change on the filter paper.
  - **Procion Red Amylopectin (PRA) or Phadebas** reagents are the most commonly used.

- **Urine**: Stains may fluoresce or luminesce under ALS, but diluted stains are more difficult to detect. Relies on two organic compounds for detection:
  - Urea
  - Creatinine
- Both urea and creatinine are found in other body fluids such as:
  - Perspiration
  - Blood
  - Saliva
  - Semen
- **Vaginal Secretions**: Are usually identified on the basis of detecting glycogenated epithelial cells. Glycogenated cells are absent from pre-pubescent females and are uncommon in postmenopausal women. They are also not unique to the vaginal tract and can be found in smaller numbers in the mouth and in the urethral tracts of males.
  - **Periodic Acid-Schiff (PAS) Reagent**: Serves to stain the glycogen in the cellular cytoplasm a bright magenta color.

Chapter 8 Review Questions:

1. **What two environmental factors are most important to consider in preserving blood evidence?** Heat and Humidity.

2. **List three possible causes of false positive reactions with presumptive screening tests for blood**. Misleading results usually can be attributed to chemical oxidants (often producing a reaction before application of the peroxide), plant materials (vegetable peroxidases and thermolabile and can be destroyed by heat), or materials of animal origin (to include human) which are not blood but may contain contaminating traces of blood.

3. **Describe the principle behind a presumptive test for blood (what is done and what it means)**. One method of applying the presumptive test involves sampling a questioned stain with a clean, moistened cotton swab and adding a drip of the color reagent solution followed by a similar amount of hydrogen peroxide. With this procedure, the immediate development of the color typical of the particular reagent used indicates the presence of blood in the test sample. Alternatively, the evidence could be sampled by removal of a thread or fragment of dried material and testing it with the above reagent in a spot plate. Color development would then be observed in the spot plate as well. Immediate (within a few seconds) reading and recording of results is an important aspect of test result interpretation. A clearly negative result may appear positive several minutes after the test is completed due to a slow oxidation that often occurs in air. These test are not usually affected by the age of the stain.

4. **An analyst conducted a phenolphthalein test on a stain he thought looked like blood. He observed a positive test immediately after adding the phenolphthalein reagent. He concluded that blood was, in fact, present. Was he correct?** The reagent consists of

reduced phenolphthalein in alkaline solution, which is oxidized by peroxide in the presence of hemoglobin in blood. As with any of the catalytic tests the result is read immediately. A positive result a minute or more after the test is performed is usually not considered reliable. False positives usually are not really positives, in that the reaction is often not the characteristic pink but usually some other color change.

5. **True or false: Luminol is so sensitive that a positive reaction can be taken to prove that blood is present**. False. Luminol is one of the most sensitive of the presumptive tests and is capable of detecting traces of blood in parts-per-million concentrations. Presumptive being the key word. You would still need to run a confirmatory test. Luminol will react with other items so it is always best to do the final confirmatory test to prove without a doubt that you have blood.

6. A person having the A antigen on his or her red cells will have serum antibodies that will agglutinate cells from:

   b. _____ a group "A" person
   c. ___**X**___ **a group "B" person**
   d. _____ a group "O" person
   e. _____ a group "AB" person

7. **When called to testify regarding evidence he had examined, an analyst was questioned about the possibility of errant enzyme results being introduced into the evidence as a result of inadequate preservation. How should he have responded?** Inadequate preservation would be heat and humidity. A change in the molecule's physical structure or the ability to perform its chemical task will often result in an inability to detect any phenotype in evidentiary stains. The result of subjecting evidence to unfavorable conditions is likely to be the loss of any detectable phenotypes rather than the introduction of new ones.

8. **Define polymorphism**. May be described as the occurrence in a population of two or more genetically determined alternative phenotypes with frequencies greater than could be accounted for by mutation. Two or more alleles for the production of the enzyme exist in the population. If enough samples are analyzed, they will be observed.

9. What are the five classes of serum proteins?

10. **Where in the male reproductive tract is acid phosphatase produced**? Seminal acid phosphatase (SAP) is a phosphatase found in human semen at uniquely high levels compared with other body fluids and plant tissues. In males, puberty stimulates the large-scale synthesis of SAP by secretory epithelial cells that line the prostate gland. SAP levels remain high until the age of about 40, after which they gradually decline. No correlation exists between the level of SAP and the number of sperm cells present in an ejaculate, and

no variation has been found between males with normal sperm count and those who are clinically infertile or who underwent vasectomies.

11. **Name two tests considered confirmatory for the presence of semen**.
    a. Microscopic Identification of sperm cells.
    b. Prostate-Specific Antigen (PSA)

12. **Give reasons for the absence of tails on spermatozoa on a microscope slide preparation**. Certain disease states, genetic conditions, excessive abuse of alcohol or drugs, prolonged exposure to certain chemicals, and elective surgery.

13. How long might seminal fluid constituents be detectable after deposition (a) inside the vagina, (b) in dried form, and (c) on fabric after laundering or dry cleaning?

14. **beta-Amylase is found in plants. Will plant extracts or stains react with the Phadebas test? Why or why not?** Not in the book. Traditionally, forensic tests for saliva relied primarily on the detection of alpha-amylase, an enzyme sometimes referred to as ptyalin in older references. Amylases are ubiquitous enzymes found in both animals and plants. They are responsible for catalysis of the component of starch, amylose, and amylopectin into smaller, less complex sugars. Amylases can be subdivided into alpha and beta categories. Beta-amylase are found in plants and alpha-amylases in animals, including humans. Beta-amylase attach only the bonds at the end of polyglucan chains.

15. **Assume that you detected amylase using a Phadebas press test on a pair of underpants worn after a sexual assault in which cunnilingus is alleged. Discuss the factors that would determine your choice of area for DNA analysis**. The reagent is dissolved and applied to large sheets of filter paper, which can then be placed on an item to map the location of amylase-containing stains for further analysis. This is called the press test. It is used clinically to detect alpha-amylase in urine, serum, and plasma, which may denote certain medical conditions, such as pancreatitis.

16. **Why is it preferable to identify both urea and creatinine in suspected urine stains**? It is advisable in the forensic context to attempt to identify more than one component for confirmation of urine due to the ubiquity of the substances in questions. Urine detection relies on identifying two organic compounds: urea and creatinine. Both components are found in other body fluids such as perspiration, blood, saliva, and semen.

Chapter 9: DNA Typing

- **DNA Molecule**: A long double-stranded molecule that in the cell is found in a twisted ladder shape referred to as a double helix.
- **Nucleotide (A,T,C,G)**: Composed of (A) Adenine, (T) Thymine, (C) Cytosine, (G) Guanine, nucleotides. (A only pairs with T, and C only pairs with G except during a mutation).
    - Defined as the unit consisting of the base (A,C,G, or T) connected to a sugar molecule and phosphate group.
    - The sugar molecule and Phosphate group constitute the backbone of the helix.
- **Francis Crick and James Watson**: Proposed that DNA was a double helix about 60 years ago.
- **Female / Male**: Females inherit X from mother X from father. Males inherit X from mother Y from father.
- Mature red blood cells, although important, does not have a nucleus and therefore lack nuclear DNA.
- **Sir Alec Jeffreys**: Geneticist at Leicester University developed DNA testing.
- **Colin Pitchfork**: January 1988 became the first criminal caught with DNA evidence and was sentenced to two life sentences. He was a local baker. There was a cook who had confessed to this murder already. DNA testing exonerated him for a crime he didn't commit by DNA (same case).
- **CODIS:** Combined DNA Index System.
- **Haploid Human Genome**: (Contained in a sperm or egg cell) Contains approximately 3 billion base pairs.
    - 3% = DNA sequences that code for proteins
    - 97% = Noncoding regions (do not code for proteins). Most of it is repetitive
        - These interspersed repetitive sequences account for about 50% of the human genome.
        - Simple sequence repeats such as **Microsatellites** and **Minisatellites** are known as **Short Tandem Repeats (STR's)** and **Variable Number Tandem Repeats (VNTR's)**. They are the components of the repetitive DNA known as **Satellite DNA**.
- **Microsatellites**: Comprise a simple class that consists of 2 to 7 base pairs in each tandem repeat unit called short tandem repeats (STR's).
- **Minisatellites**: Simple sequence tandem repeat polymorphism in which the core repeat unit is usually 10 to 50 nucleotides long; variable number of tandem repeats.
- **Heterozygosity**: When an individual has two different copies (or alleles) of a gene or locus.
- **Homozygous:** When a person has the same number of copies at both loci. Refers to both alleles being the same at a specific genetic locus.
- **Nucleic acid**: The source for most crime scene DNA isolations is usually extracted from:
    - Blood
    - Semen
    - Bone
    - Hair
    - Dried skin

- **Nucleases:** Enzymes that are responsible for most of the environmental breakdown of DNA. These substances are found nearly everywhere, including on the surface of our skin, where they protect us from foreign DNA invasion.
- Several factors are known to contribute to DNA breakdown:
    - Heat
    - Water/Humidity
- DNA is heated to approximately 95 degrees Celsius to break the connecting bonds and produce separate strands, each constituting a half molecule of DNA.
- **Denaturing**: Melting; the strand separation process. Halves separate to serve as a template for making a copy of DNA. Once you split, you then would synthesize new complements, making two new strands of DNA where there had been originally just one.
- RFLP analysis allows for measurement of the size of DNA fragments. It is based on a variation in the number of times a sequence of base pairs in DNA is repeated, much as with STR's: however, RFLP fragments are considerably longer than STR repeats. It is now obsolete testing due to the cost and difficulty of the testing.
- Copying DNA is conceptually simple. The steps are as follows:
    - Obtain a sequence of double-stranded DNA
    - Split into separate strands
    - Synthesize new complements
- **Polymerase Chain Reaction (PCR)**: A reaction used to make copies of segments of DNA; biotechnological process of DNA amplification.
    - DNA is composed of two half-molecules that copy themselves on the basis of A-T, G-C.
    - We must have the two DNA strands (denaturation). Three major steps:
        - Denaturing: separating the two strands of DNA.
        - Annealing: Primer binding; pairing of complimentary strands.
        - Extension
- **Dr. Kary Mullis**: Awarded the Nobel Prize in 1993 in chemistry for contributions to the developments of methods within DNA-based chemistry, specifically for his invention of the polymerase chain reaction (PCR) method. He discovered the ability to split DNA at 95 degrees Celsius. This is hot springs polymerases. The process could now be automated.
- **Amplicons:** Product of the amplification of DNA copying; copies of the original piece of DNA.
- **Primer:** The choice of specific sequences is a technical matter of primer selection. A primer is a necessary ingredient for beginning the DNA replication process. Primers specifically define which region of the DNA will be amplified through base pair complementarity.
- **Short Tandem Repeat (STR's)**: A simple short sequence of DNA that contains a repeated pattern of A, T, C and G; usually consists of repeated tetramers (tetranucleoties: four bases repeated in an array.)
- **Capillary Electrophoresis**: Allows for fast and automated methods for genetic profiling with the use of small capillary; detected by laser-induced fluorescence. Amplicons are labeled with one of four fluorescent dyes to organize capillaries by size and charge.

- **Mitochondrial DNA (mtDNA)**: Is located outside the nucleus of the cell in the energy-producing organelles known as mitochondria. It is maternally inherited; all members of a maternal lineage will share the same sequence. Forensic advantage: Great number of mitochondria per cell and DNA molecules per mitochondria.
- **Y-STR Typing**: Is the only test that can unambiguously determine what a male has contributed to a mixed sample. They are advantageous in analyzing fingernail scrapings from a female assault victim, separating out the male skin cells from a ligature used in the strangulation of a female victim, etc.

Chapter 9 Review Questions:

1. **Where in the cell is DNA located?** In the nuclei of all types of cells in the human body except mature red blood cells.

2. **Name three types of human cells that contain DNA**. Mature red blood cells, although important, do not have a nucleus and therefore lack nuclear DNA. White blood cells are where the DNA will be located in blood. Sperm and the egg

3. **What was the contribution of Watson and Crick to the understanding of DNA**? About 60 years ago, an English graduate student named Francis Crick and an American post doctorate researcher named James Watson first proposed that the structure of DNA was a double-helix. The two individual strands curl around each other in a shape of a twisted ladder. The significance of Watson and Crick's DNA model has been enormous in the field of biology. In addition to opening the doors for nearly every breakthrough concerning our understanding of DNA replication, transcription, and translation, Watson and Crick helped us to understand how we can manipulate DNA to perform the tests that have become central to any forensic investigation.

4. **What is the purpose of the Combined DNA Index System (CODIS)**? The CODIS database system has become invaluable for linking crimes, identifying suspects, and investigating cold cases. It is a database created by the FBI around 1988. They compiled convicted offender database system that will talk with national state and local agencies that have the ability to add cases into the CODIS system.

5. **Why is polymerase chain reaction (PCR) important in DNA analysis**? The process of splitting DNA into two strands could now be automated. DNA could now be copied over and over and scientists could produce as much DNA as required to run tests. After 20 to 30 rounds of DNA copying, we will have millions of identical copies of the original or target pieces of DNA. These copies are known as **amplicons**.

6. **Where is mitochondrial DNA found in the body**? Is located outside the nucleus of the cell in the energy-producing organelles known as mitochondria. The forensic advantage of this type of DNA analysis is the great number of mitochondria per cell and DNA molecules per mitochondrion. The mitochondrial genome may be present in a cell from 100 copies to several thousand. A single hair root can be easily typed using mitochondrial analysis, as can hair shafts, ones, teeth, ancient samples of tissue, saliva, blood, semen and any sample that is amenable to DNA sequencing.

7. **Describe the process known as PCR or polymerase chain reaction**: Size is not usually a major factor in PCR testing, as small fragments of less than 1000 bases are needed for analysis. The DNA is heated to approximately 95 degrees Celsius to break the connecting bonds and produce separate strands, each constituting of a half molecule of DNA. This strand separation process is called denaturation or melting. Now each half of the separated DNA molecule can serve as a template for making a copy. The PCR process consists of three major steps: **denaturing, annealing, and extension**. This process is repeated 20 to 30 times. The denaturing step is the separation of the two strands of the DNA molecule. This makes both strands available for further amplification once the strands or templates are primed. This strand separation occurs when the DNA double helix is heated between 94 and 96 degrees C., at which point single-stranded DNA primer sequences from 6 to 39 base pairs bind to the sequence exterior (flanking region) of the target we want to amplify. Primer binding is also called annealing. Next a thermostable DNA polymerase adds bases such as A, T, G, or C to the single strand template, thus making a new complementary single strand. The primer initiates the extension process. Because primer sequences are present in vast excess, the process may be repeated over 2 to over 30 cycles, thus creating millions of copies via an exponential chain reaction. This yields the DNA required for comparative size or length analysis.
    a. Obtain a sequence of double-stranded DNA
    b. Split it into separate strands
    c. Synthesize new complements

8. **Who was the first scientist to use RFLP in forensic case**?
    a. Colin Pitchfork
    b. Tommie Lee Andrews
    c. Alec Jeffreys
    d. Joseph Castro
    e. O.J. Simpson

9. **Which of the following is a class of repetitive DNA**?
    a. Structural genes
    b. Microsatellites
    c. Operator genes
    d. Homologous genes
    e. siRNA

10. **Which of the following is not a step in polymerase chain reaction**?
    a. Denaturation
    b. Lysis
    c. Polymerization
    d. Annealing
    e. Translation

Chapter 10: Forensic Toxicology

- Two types of forensic scientists work with drugs and poisons:
  - Toxicologists
  - Seized Drug Analysts
- **Toxicologist**: The analysis of biological samples such as blood and tissue for the presence of drugs, poisons, and their metabolites. Works in concert with the ME's office to assist in determining the manner and mechanism of deaths.
- **Toxicology**: Is the study of poisons; examination of all aspects of toxicity that may have legal implications. Employed today primarily in two general areas:
  - Postmortem drug testing
  - Work place drug testing (testing biofluids: urine/blood)
- **SOFT = Society of Forensic Toxicologists**
- **ADME** = A way to track drugs in the body in a general sense.
  - A = Absorption
  - D = Distribution
  - M = Metabolism (takes place primarily in the liver)
  - E = Excretion
- The most common types of toxicological samples:
  - **Blood**: Because the concentration of toxin present in blood often correlates more closely w/lethal outcome other specimens, blood is most important specimen in postmortem toxicology.
  - **Urine**: Preferred for workplace testing. Potential problem w/urine is that the correlation between the drug concentration in the urine and drug effects is usually poor.
  - **Gastric Contents**: Good for sudden deaths where stomach is full of lethal agent.
  - **Vitreous Humor**: Fluid in eyeball. Is resistant to postmortem decay. Used only in postmortem examinations.
  - **Bile and liver**: Likely to contain significant quantities of most drugs and may permit identification of an agent that caused death even when the substance cannot be found in the blood. Bile drains from the liver and is very rich in certain types of drugs, such as opiates.
  - **Breath:** The concentration of blood alcohol is about 2100 times greater than the concentration of breath alcohol. This is how you can measure blood alcohol levels.
- **Opiates**: Derived from the opium plant, including morphine and codeine. Heroin is produced from morphine. Causes profound euphoria as well as relieve pain. Considered a **depressant** because it reduces muscle activity, depressed respiration and heartbeat, and an inclination to sleep. In overdose, death is usually seen by paralysis of the respiratory center.
  - Codeine
  - Heroin
  - OxyContin
  - Fentanyl

- **Amphetamines**: **Stimulants** that create an excitatory condition characterized by elevations of heart rate, blood pressure, and respiratory rate. Intense euphoria. Compounds are numerous and include:
    - Ephedrine
    - Phenylephrine
    - Phenmetrazine (all starter chemicals for methamphetamine).
- **Cocaine**: **Stimulant** that resembles amphetamine in its abuse potential and pharmacological responses. Is a natural product found in the coca leaf. Erythroxylon Coca, the source of cocaine, grows in parts of South America.
- **Crack Cocaine**: (Introduced into the U.S. in 1980's). Cocaine is alkaline in nature and is usually extracted with hydrochloric acid = cocaine hydrochloride. Cocaine Hydrochloride may be treated with a base and extracted into a solvent (ether) creating "free base" or "crack" cocaine. Crack cocaine has a lower boiling point allowing for smoking the drug. When a drug is smoked, the large lung surface absorbs larger amounts of the drug into the system, causing a higher high.
- **Marijuana (Cannabis Sativa)**: Is a name that applies to part of the cannabis sativa plant. Many psychoactive compounds come from this plant. Drug state includes euphoria, perceptive alterations, memory impairment.
    - **Tetrahydrocannabinol (THC)**: Major active agent and is present to the extent of 2-6% by weight in cannabis. (Hashish: the oily extract with higher THC content = 12%).
- **Bath Salts**: Analog Drug, which mimic the effects of dangerous illegal drugs. Typically contain compounds that produce physiological responses similar to stimulants such as methamphetamine or mephedrone. Causes hallucinations and other side effects. Very dangerous. Toxicologists struggle to keep up with the new ones that appear.
- **Cannabinomimetics**: Synthetic cannabinoids. Sold as **K2** and "**Spice**."
    - **JWH Compound**; Named for John W. Huffman who manufactured it in 1995. Synthetic of marijuana.
- **Polypharmacy**: Deaths involving combinations of drugs (prescribed or illicit). This trend is called polypharmacy. Alone, any one drug would not cause death, but in combination such drugs can become more dangerous.
- Many deaths are due to chemicals that are not medicinal but are encountered in the environment or in industrial activity. The major members of this category are:
    - Alcohols
    - Cyanide
    - Carbon monoxide
    - Hydrocarbons
- **Alcohol**: Ethanol is beverage alcohol. **Depressant**. Other low-molecular-weight alcohols include methanol and isopropanol. Alcohols enter the membranes of nerve cells and disrupt their normal nerve-to-nerve signaling. 90 minutes after ingested is the approx. peak blood levels. It is preferable to use the GC when measuring blood alcohol levels. Concentrations greater than 350 milligrams per deciliter will cause death.
- **Cyanide**: Toxic substance found in nature in numerous forms. The fastest acting form = hydrogen cyanide gas. Death will occur in less than one minute if enough inhaled. Cyanide

binds to ferric ions in cytochrome oxidase, an enzyme in the electron transport system within the mitochondria of cells. Without the biochemical energy generated from electron transport, life is not possible.
    - Normal levels in blood = >40 ng/mL
    - Stupor levels in blood = <1000 ng/mL
    - Fatal levels in blood = <2500 ng/mL
- **Carbon Monoxide (CO)**: Leading cause of deaths related to toxic substances; fires, faulty heaters (low oxygen + heat create = CO). CO binds hemoglobin much more tightly than oxygen so hemoglobin is unable to fulfill its normal function of transporting oxygen to tissue.
    - Carboxyhemoglobin levels that exceed 60% are at a great risk of death.
- **Immunoassays**: Tests utilizing antibodies that react with a drug or substance. Antibodies are used because they enable the reagents to react only with a substance that recognizes the antibody. Immunoassays are:
    - Objective
    - Relatively specific
    - Capable of high sensitivity
    - Compatible with automation
    - They are NOT 100% specific but if follow up with a confirmatory test this is not a problem.
- **Thin-Layer Chromatography (TLC)**: The specimen is extracted into an organic solvent and spotted onto a glass plate coated with silica; the plate is placed into a tank that contains a mobile phase that migrates up the plate. Toxins are identified on the basis of the distance and color with reagents. This is a screening technique.
- **GC-MS**: One of the most powerful instruments used to identify compounds in forensic chemistry. Identification is based on its retention time plus its unique mass spectrum.
    - **Thermolabile**: GC-MS cannot be used with 80% of organic chemicals either because the substance being tested is thermolabile (breaks down at elevated temperature) or hydrophilic.
- National Institute of Standards and Technology (NIST): Has a library of over 140,000 compounds that can be searched for matches to the GC-MS.
- **Liquid Chromatography – Mass Spectrometry (LC-MS)**: A technology in which a liquid chromatography replaces the gas chromatograph used in GC-MS. Compatible with virtually every known organic chemical (does not have to be heated for conversion to gas.)
- **Metal Analysis**: Many metals are toxic to humans. Those that present the greatest danger include:
    - Lead
    - Mercury
    - Arsenic
    - Cadmium
- Other metals that are of importance to forensic toxicologists include:
    - Iron
    - Nickel

  - Copper
  - Zinc
  - Bismuth
  - Thallium
- **Colorimetric Assays**: Measurement of metal. It is a simple reagent and an inexpensive photometer that are used.
- **Marsh Test**: Was one of the first and most famous color-based tests for arsenic. Was invented by a Scottish chemist James Marsh in 1836. Could detect arsenic in tissue samples or stomach content.
- **Arsenic**: Builds up in the system. Poisoners could kill their victims gradually over weeks by giving small daily doses.
- **Inductively Coupled Plasma – Mass Spectrometry (ICP-MS)**: Is the best and most modern technique for metal analysis.
- **Toxicokinetics**: Knowledge in how drugs and poisons move through the body.
- **Toxicogenomics:** Describes how genetic factors play a role in toxicity of an ingested drug or poison.
- **Postmortem Redistribution**: A factor that complicates the interpretation of postmortem drug levels. The concentration changes that occur after death as drugs move from one region of the body to another.

Chapter 10 Review Questions:

1. **What are the three areas covered by forensic toxicology**? Toxicology is the study of poisons. Forensic toxicology is employed today primarily in two general areas. The first is postmortem drug testing. This consists of death investigation with a goal of establishing whether drugs were the cause or contributing factor in death. The second major area of forensic toxicology is workplace drug testing. This consists of testing biofluids, primarily urine and blood, from employees or job applicants for the possible presence of drugs. Drugs, Poisons, and Biological Evidence. The main emphasis is to determine if death was accidental, suicidal or homicidal.

2. **Name six specimen types that are often tested in forensic toxicology. Under what circumstances is each specimen preferred?**
   a. **Blood**: Because the concentration of toxins present in blood often correlates more closely with lethal outcome than concentrations in other specimens, blood is the most important specimen in postmortem toxicology. Blood is also preferred to establish DUI.
   b. **Urine**: is preferred for workplace testing and sports testing; it does not require any invasive sampling such as drawing blood. A potential problem with urine is that the correlation between the drug concentration in the urine and drug effect is usually poor.
   c. **Gastric Contents**: May be beneficial in the case of sudden death of a person who has large quantities of a lethal agent in his/her stomach. If the manner of death is suicide, large amounts of drugs in the stomach may help to establish this.

d. **Vitreous Humor**: the fluid found in the eyeball is resistant to postmortem decay; it is used only in postmortem examinations.
e. **Bile and Liver**: are likely to contain significant quantities of most drugs and may, on occasion, permit identification of an agent that caused death even when that substance cannot be found in the blood. Bile drains from the liver and is very rich in certain types of drugs, such as opiates.
f. **Breath**: a relationship exists between alcohol in the bloodstream and alcohol in the lung such that, on average, the concentration of blood alcohol is about 2100 times greater than the concentration of breath alcohol. For this reason, one can measure the breath alcohol and infer the corresponding alcohol concentration in the bloodstream.

3. **Name the NIDA 5. Draw a table showing the following characteristics of each drug: structure of a representative molecule, drug group, symptoms of overdose, and drug source**.

4. **Name several groups of medicinal drugs often involved in fatalities. What characteristics render a drug most likely to be associated with overdose deaths?**
    a. **Opiates**: Semisynthetic opiates are those made by a simple modification of the morphine or codeine molecule. Relieves long term pain. Opiates are classified as depressants. Accordingly, they produce, in addition to the initial euphoria, reduced muscle activity, depressed respiration and heartbeat, and an inclination to sleep. In overdose, they cause death, usually by paralysis or the respiratory center.
    b. **Amphetamines**: Many compounds are sold by prescription or over the counter and have decongestant, anti-insomniac, and anorexic actions. Example: ephedrine. When they are manipulated into methamphetamines is when they become addictive. They are considered stimulants. They elevate heart rate, blood pressure and respiratory rate. Provokes intense euphoria.

5. **A 210-pound male consumes three highballs each of which was made with 2 ounces of 80-proof whiskey. What is the expected peak in his blood alcohol concentration**?

6. **Name three methods for drug screening and describe the advantages and disadvantages of each**.

    a. **Immunoassays:** Are tests in which antibodies are used. An antibody is prepared against an analyte such as morphine or methamphetamine. There are many immunoassay methods based on this fundamental principle of antigens binding with antibodies and many ways in which the concentration of the drug is measured. Immunoassays are objective, relatively specific, capable of high sensitivity, and compatible with automation. Their major drawback is lack of 100% specificity, but this is not an insurmountable problem because

immunoassay positive test results are followed by confirmatory testing. Also, because immunoassays are used only for screening.

b. **Thin-Layer Chromatography**: Chromatography is a means of separating chemicals. In TLC the specimen is extracted into an organic solvent and spotted onto a glass plate coated with silica. The plate is placed into a tank that contains a mobile phase that migrates up the plate. The solvent moves up the plate, carrying sample molecules along with it. Toxins are identified on the basis of the distance they migrate up the plate and on the basis of the colors they produce with various identifying reagents. TLC is inexpensive, and is an excellent screening technique.

c. **Gas Chromatography-Mass Spectrometry**: One of the most powerful instruments used to identify compounds in forensic chemistry is the combination of gas chromatography, which separates compounds from one another, with a detection system all in one instrument. Rather than using a solvent, the mobile phase is an inert gas (carrier gas). The time it takes the gas to travel through the column, where they react with the stationary phase, is how the chemical is determined in the unknown. The retention times are different for all chemicals. The mass spec added to this machine allows for absolute specificity as to what chemical is being tested.

7. **Contrast gas chromatography with and without a mass spectrometer detector. Describe the advantages of the latter technology**. One of the most powerful instruments used to identify compounds in forensic chemistry is the combination of gas chromatography, which separates compounds from one another, with a detection system all in one instrument. Rather than using a solvent, the mobile phase is an inert gas (carrier gas). The time it takes the gas to travel through the column, where they react with the stationary phase, is how the chemical is determined in the unknown. The retention times are different for all chemicals. The mass spec added to this machine allows for absolute specificity as to what chemical is being tested. Cannot be used to test 80% of organic chemicals because the substance being tested is thermolabile (breaks down at elevated temperature). So you have to use Liquid Chrom-MS.

8. **What are three methods of metal analysis? Which is the optimal method and why**? Many metals are toxic to humans. Those that present the greatest danger include lead, mercury, arsenic, and cadmium.

a. **Colorimetric Assays**: Only simple reagents and an inexpensive photometer are needed. Methods based on colorimetric endpoints were developed long ago, many in 19th century. **Marsh Test** is the most commonly known and is used to test for arsenic. Metal assays based on photometry have high detection limits. This disadvantage is partly circumvented by using a large specimen size.

b. **Inductively Coupled Plasma-Mass Spectrometry (ICP-MS):** is the best and most modern technique for metal analysis. Cost for the machine limits its availability. Argon atoms in the ICP-MS torch are subjected to radiofrequency energy that

makes them collide. This drives the temperature of the torch to greater than 6000 degrees C. Atoms in the specimen are ionized and then directed into a mass detector where they can be separated on the basis of their masses and charges.

Describe the process of interpreting drug results in the context of pre-employment drug testing. Why is drug testing for employed individuals more difficult? The law only allows random drug testing for employees only if they have specific occupations, such as custom agents and police officers, among others. In these occupations, the law usually places the public safety above the employee's right to privacy. Employees may also be ordered to provide specimens for drug testing for cause, that is, if they appear to be impaired at work as a result of abusive use of alcohol or other drugs. It is also important to recall that abusable substances often have legitimate medicinal applications. Consequently, you should bear in mind that many of the compounds cited below are used by persons who derive medical benefit from them. Despite their chronic use of such substances, many of these persons never use them in an abusive manner.

Chapter 11: Seized Drug Analysis

- Drug: any substance that when ingested causes a physiological change.
- **Controlled Substances Act (CSA**): Title 21 of the United States Code (21 USC) that regulates the possession and/or use of a controlled substance.
    - **Schedule 1: high potential for abuse; heroin, LSD, marijuana.**
    - **Schedule 2: morphine, cocaine.**
    - **Schedule 3: steroids, barbiturates.**
    - **Schedule 4 &5: over the counter meds; cough syrup.**
- **Comprehensive Drug Abuse and Prevention Control Act in 1970**: The CSA's were part of this act. The act classifies drugs into one of five schedules based on medical use and the danger of physical and psychological dependence. Each schedule also specifies penalties as well as how drugs can be obtained, and if a permit is needed.
- **Drug Enforcement Administration (DEA)**: The Comprehensive Drug Act gave the DEA ability to add substances to the schedule without having to wait for a more formal and lengthy procedure.
- **1986 the Anti-Drug Abuse Act**: Addressed analog drugs synthesized by clandestine labs.
- Immunoassays rarely used in drug testing instead chemists rely on color-based testing and reagents.
- **SWGDRUG Guidelines**: Types and minimum number of tests required to identify seized drugs. Three categories of analytical techniques are used for the identification of controlled substances:
- **Category C. Non-Specific Techniques:**
    - **Chemical Color Test:** A technique that uses the colors produced by chemical reactions to provide information regarding the structure of the substance being tested
    - **Fluorescence Spectroscopy:** An analytical technique that uses the release characteristic wavelengths of radiation following the absorption of electromagnetic radiation (fluorescence) to establish a compound's potential identity.
    - **Immunoassay:** A laboratory technique that uses the binding between an antigen and its homologous antibody to identify and quantify the specific antigen or antibody in a sample
    - **Melting Point:** The temperature at which a solid becomes a liquid at standard atmospheric pressure.
    - **Ultraviolet (UV) Spectroscopy:** A technique that uses the absorption of ultraviolet radiation to classify a substance.
- **Category B. Moderately Specific Techniques:**
    - **Capillary Electrophoresis (CE):** A separation technique using the differential movement or migration of ions by attraction or repulsion in an electric field through buffer-filled narrow-bore capillary columns as an identification tool.
    - **Gas Chromatography:** A separation technique that uses gas flowing through a coated tube to separate compounds by their size, weight, and chemical reactivity with the column coating.

  - **Liquid Chromatography:** A separation technique that uses liquid flowing through a coated tube to separate compounds by their size, weight, and chemical reactivity with the column coating.
  - **Microcrystalline Tests:** A technique that uses the microscopic crystals produced by chemical reactions to provide information regarding the identity of the substance being tested; a series of positive microcrystalline tests can be considered to be a conclusive test.
  - **Pharmaceutical Identifiers:** Comparing the physical characteristics of a commercially produced pharmaceutical product to known reference material to tentatively establish the composition of the preparation.
  - **Thin-Layer Chromatography:** A technique that uses solvents traveling through a porous medium to separate compounds by their chemical reactivity; can be documented through photographing or photocopying the developed thin-layer plate.
- **Category A. Specific Examinations**
  - **Infrared Spectroscopy:** A technique that uses the absorption of infrared radiation to produce a "chemical fingerprint" of a substance; can be used in conjunction with gas chromatography.
  - **Mass Spectroscopy:** A technique that uses molecular fragment (ion) patterns to produce a "chemical fingerprint" of a substance; can be used in conjunction with gas and liquid chromatography.
  - **Nuclear Magnetic Resonance Spectroscopy:** A technique that monitors the splitting of nuclear energy levels within a molecule when it is exposed to oscillating magnetic fields.
  - **Raman Spectroscopy:** A technique that uses the inelastic scattering of light by matter to produce a "chemical fingerprint" of a substance.
- The identification of controlled substances is divided into two categories:
  - Botanical
  - Chemical
- **Botanical Examinations**: Identify physical characteristics specific to plants that are considered controlled substances. They are the most common examinations performed in the controlled substance section of the lab. Marijuana exceeds 50% of the caseload.
  - When doing the identification, the examiner is identifying the plants and plant material, not the specific psychoactive ingredients.
- **Chemical Examinations**: Use wet chemical or instrumental techniques to identify specific substances that are controlled by statue.
- **Alkaloids**: Any of a class of nitrogenous organic compounds of plant origin that have pronounced physiological actions on humans.
- **Marijuana**: Cannabis Sativa L.; the identification of marijuana as physical evidence is a two-step process.
  - Establish the plant or plant material as marijuana through its physical characteristics.
  - Establish the presence of the plant resin that contains the psychoactive components.

        - **Macroscopic** Examination: Class characteristics; distinctive leaf structure, serrated edges. Plat stems fluted.
        - **Microscopic** Examination: Cystolithic (bear-claw shaped) hairs on top surface, fine hairs on the underside.
        - **Duquenois-Levine Test**: Chemical color test used to confirm the presence of cannabinoids and THC.
        - **Thin-Layer Chromatography (TLC)**: Specimen is extracted into the organic solvent and spotted onto a glass plate coated with silica; the plate is placed into a tank that contains a mobile phase that migrates up the plate. Separates cannabinoids in the resin.
- **Hashish**: The resin from marijuana that has been isolated from the plant material; found as oil or cake-form. Duquenois-Levine Test may be all that is required to identify this. But you can back up with a Mass Spec.
- **Peyote:** A small Mexican cactus Lophophora Williamsii. Each variety of the plant contains mescaline which is a hallucinogen. A confirmatory test is not required for mescaline because the examiner is identifying the plant not the psychoactive components. Identification begins with:
    - Macroscopic examination: Approximately 1 inch in diameter, divided into segments the button contains a small white tuft of material.
    - Microscopic examination: None that can identify the plant.
    - Chromatographic examination is used to identify a pattern of alkaloids.
- **Mushrooms:** The illegal components of mushrooms are psilocin and psilocybin. Over a dozen species of mushrooms contain these compounds.
    - Physical Identification: Body off white in color with blue gray staining. Caps range from off white to light brown or tan.
    - Chemical test: Testing for psilocin and psilocybin using chemical and TLC.
- **Wet Chemical Procedures**: Used as a screening method or for sample preparation. Tests include the following:
    - Chemical color tests
    - Microcrystalline tests
    - Thin layer chromatography
    - Liquid extraction
- **Chemical Color Tests**: Are chemical reactions that provide information regarding the structure of the substance being tested. Some tests may be conducted in a sequential fashion utilizing multiple reagents. Colors can be influenced by:
    - Concentration of the sample,
    - Presence of diluents and adulterants,
    - Age of the reagent.
- **Microcrystal Tests**: Used as a screening tool to confirm an identification made with other testing methods. A reaction between the compound of interest and the test reagent forms a solid compound that is not soluble in the test drop. The solid forms uniquely shaped crystals that can be observed with a microscope. Comparisons between the crystals of the

known and unknown should be done using the same sample concentration with the same crystal reagent to prevent:
    - Differences in crystals can be caused by:
        - Impurities in the unknown
        - Concentration of the solution
        - Reagent age
        - Polymorphism
- **Extractions**: Are used to separate the compound of interest from the rest of the sample. The basic types of extractions include:
    - Physical extractions
    - Dry washing
    - Dry extractions
    - Liquid/liquid extractions
- **Physical Extraction**: Are the simplest. Physically removing the particles of interest from the balance of the sample for later analysis.
- **Dry Extraction**: Uses a solvent to dissolve and remove the compound of interest from the sample matrix.
- **Liquid/Liquid Extraction**: Utilizes the solubility characteristics to separate a substance from a mixture.
- **Infrared Spectroscopy (IR)**: Is one instrument that is used in seized drug analysis but not often in forensic toxicology. Suited for solid samples that are relatively pure. It involves energy from the infrared region of the electromagnetic spectrum. Humans can sense IR radiation as heat. It uses a compound's ability to absorb IR light as a means of identification. It analyzes the vibrations of different parts of a molecule when it is exposed to IR light. The pattern that results is considered to be a "chemical fingerprint" that is then compared to a reference library to identify the substance.
- The investigation of clandestine lab activity can be divided into five sections, all of which should involve a forensic chemist:
    - Recognizing a clandestine lab
    - Processing the clandestine lab site
    - Laboratory analysis of the evidence
    - Generating opinions from the physical evidence
    - Presenting the evidence in court

Chapter 11 Review Questions:

1. **List two plants that are considered controlled substances that require a botanical examination as part of the identification process**. Marijuana. Peyote. Mushrooms. Opium.

2. **When is it necessary to confirm the identity of the controlled substance in plant material? Give an example**.

a. **Hashish**. The resin from marijuana. This compound cannot be looked at microscopically. You would need to run it through a MS in order to find out the exact make-up of the compound. Duquenois-Levine would only fulfill one part of the identification process.
b. **Peyote**: Visual inspection is not an identification for this substance. The use of a chromatographic examination is used to confirm the identity of peyote. A confirmatory test for mescaline is not required because the examiner is identifying the plant, not the psychoactive components.

3. **List four wet chemical techniques that can be used in the analysis of controlled substances**.
   a. Chemical Color Tests (Presumptive Test)
   b. Microcrystalline Tests (Screening Test)
   c. Thin-Layer Chromatography
   d. Liquid Extraction Techniques

4. **List two wet chemical techniques that can be used as both screening tools and sample preparation techniques**. Thin-Layer and Liquid Extraction.

5. **List two disadvantages to wet chemical techniques**. Microcrystalline you have to get the mixture of the known to be as close/similar to the unknown or the test will not be exactly the same. If it is too pure the crystals will grow rapidly and look differently etc. With the color tests they are subject to human interpretation. Colors will look differently to one vs another. The substances inside the drug mixture may cause issues with the colors as well. Not easy to do on the street. All have to be done in a controlled environment.

6. **List two specific and two nonspecific instrumental techniques**. Two specific are GC/MS and the IR. Non-specific would be extraction and TLC.

7. **What information should accompany instrumental data**?

8. **When is a library search considered a confirmation and why**? The various IR spectra libraries that are available should be used as a screening tool, not as a reference for confirmation.

9. **Which instrumental technique's spectra are most subject to variations due to sample preparation techniques? Why**?
10. **List three quantitation techniques in order from most specific to least specific**.

11. **Describe the minimum qualifications for a clandestine lab chemist**. They have to have additional training in clandestine manufacturing techniques as well as inorganic analysis. This knowledge allows them to expand their analytical scheme to identify the chemicals used in the manufacturing process. Their goal is to identity the manufacturing process, not just the controlled substance final product.

Chapter 12: Arson, Fire, and Explosives

- Arson and the evaluation of physical evidence recovered from fire scenes are considered part of forensic chemistry.
- **Fire:** The rapid oxidation process with the evolution of heat and light.
- **Explosion**: Is the sudden conversion of potential energy (chemical or mechanical) into kinetic energy with a production and release of gases under pressure. These may be divided into two sub-definitions:
    - High-Order Explosion: A rapid pressure rise or high force explosion characterized by shattering the confining structure or container.
    - Low-Order Explosion: A slow rate of pressurization or low-force explosion characterized by a pushing or dislodging the confining structure or container.
- **Fire Tetrahedron**: The components necessary for a fire are:
    - Fuel
    - Heat
    - Oxygen
    - Uninhibited chemical chain reactions
- **Fuel:** Is any substance that will burn or support combustion. They exist in three different states but can only be volatized and consumed in the vapor state. (Wood doesn't burn, the vapors coming off of it burn).
- **Fuels are found in three basic states**:
    - **Solid**: Decompose with heat, vaporize, and become gases.
    - **Liquid:** Do not burn; the vapors rising from the liquids do.
    - **Gaseous vapor**: The molecules are in rapid movement and random motion. When gaseous fuel diffuse into air, the mixture may ignite or explode.
- An oxidizing agent is required to support combustion. The most common is oxygen. Normal atmospheric air contains 21% oxygen. Typically, flaming combustion occurs above 15% oxygen. Generally, the higher the ambient temperature, the less oxygen is required for combustion.
- **Carbon Monoxide**: Primary cause of death in fire fatalities. It is a fuel with an ignition temperature of 1128°F and is the likely cause of most backdrafts or smoke explosions.
- **Flashpoint**: Is the temperature at which a liquid gives off sufficient vapors to form an ignitable mixture at its surface.
- **Fire Point**: Is the temperature at which a liquid produces vapors that will sustain combustion. This is generally several degrees higher than the flashpoint.
- Flammable Liquids vs. Combustible Liquids: Generally accepted temperature used to distinguish flammable vs. combustible is 100°F. Temperatures below 100°F = flammable; temperatures greater than 100°F = combustible.
- **5 Basic Methods of Heat Production**:
    - **Chemical**: Result of rapid oxidation.
    - **Mechanical**: The product of friction.
    - **Electrical**: Product of arcing, shorting, or other electrical malfunction.
    - **Compressed Gas**: When gas is compressed, molecular activity is greatly increased. Result explosion.

  - Nuclear: Splitting of atomic particles
- **3 Forms of Heat Transfer**:
  - **Conduction**: Transfer of heat through direct contact.
  - **Convection**: Transfer of heat by a circulating medium, usually air or liquid.
  - **Radiation**: Radiated heat moving in invisible waves and rising much the same as sunlight or x-rays.
- **Chemical Chain Reaction**: Is a complex series of events that must be continuously and precisely reproduced to maintain flaming combustion. Two events must occur:
  - The oxidation reaction must produce sufficient heat to maintain continued oxidation.
  - The fuel mass must be broken down into similar compounds and liberated (vaporized) from the mass itself, and in turn, the unburned vapors must combine with available oxygen and be continuously drawn up into the flame.
- **Area of Origin:** Where the fire began. The fire will then travel along the path of least resistance. It will extend horizontally and vertically from the area of origin.
- **4 Phases of Fire Progression:**
  - **Incipient:** May last from second to several hours or days depending on the fuel or ignition source.
  - **Emergent Smoldering:** The products of combustion become increasing pronounced.
  - **Free Burning:** The rate and intensity of open burning increases. Flashover may occur.
  - **Oxygen-Regulated Smoldering**: Oxygen is depleted, fire begins to die out.
- **Glowing Combustion**: Depletion of oxygen supply causes the flaming combustion to end. Produces heavy, dense smoke and gases, which are forced from the room under pressure. The resulting superheated mixture of gases requires only a fresh supply of oxygen to resume free burning at an explosive rate, causing a Backdraft.
- **4 Fire Classifications:**
  - **Accidental**: Explainable
  - **Natural:** Act of nature
  - **Incendiary:** Intentional act of setting a fire.
  - **Undetermined:** Cause unknown, unable to be identified
- **Spoliation:** Intentional or negligent destruction or alteration of evidence.
- **Overhaul:** The inspection of and, when necessary, the movement or removal of debris in an effort to discover concealed embers or flames that might rekindle the fire.
- Documentation of the utilities, including electric, gas or other fuel services, into the structure.
- **Accelerants:** Flammable material used to start fire (solids, liquids or gas); gasoline most common. Liquid accelerants fall into two categories:
  - **Petroleum Distillates:** (Gasoline)
  - **Non-Petroleum**: (Acetone, Methanol)
- **Petroleum Distillates**: Liquid accelerant category, derived from crude oil and are also called hydrocarbons or petroleum hydrocarbons. Volatility of the individual components ranges

from extremely volatile substances such as propane to asphalt, which remains solid even at high temperatures.

- The volatility of an accelerant is an important consideration in the combustion process, determining how much residue will be left and how quickly it will evaporate after the fire is out.
- **Flash Point**: The temperature at which a liquid will give off enough vapor to form an ignitable mixture.
- The presence of accelerants can be determined in several ways:
    - Trained dogs
    - Chemical color tests
    - Portable instruments
    - Sensors
- **Gross Identification:** The most basic identification of a body, whereby a relative or friend identifies the victim by visual identification.
- A control or comparison sample is the same material removed from a different room or different area of the room than where the fire originated.
- **American Society for Testing and Materials (ASTM):** Agency that regulates the methods used by laboratories to analyze fire debris evidence.
- **GC-FID (Flame Ionization Detector):** The primary tool used to detect and identify liquid accelerants. GC-MS are rapidly replacing the FID though.
- **Weathering:** Occurs as lighter (less volatile) components of the accelerant evaporate, and the longer the sample sits before collection the more sever the weathering effects.
- Arson samples are introduced into the GC using several methods:
    - **Cold Headspace**: Can punctured, syringe withdraws a sample from headspace
    - **Heated Headspace**: Prior to syringe introduction, the can is heated
    - **Extraction**: Solvent and sample
    - **Purge and Trap**: Filter air pumped through can, exit hole there is a charcoal trap that catches compound.
    - **Charcoal Strip/Solid Phase**:
- **Explosives:** Chemical compounds or mixtures that decompose rapidly to produce heat and gas. What distinguishes an explosion from combustion is the speed at which the reaction occurs. Explosives can be categorized in two ways:
    - **Low Explosives**: Burn very quickly and must be kept in a confined space to actually explode. Sometimes referred to as "Burning explosives". Sensitive to heat, friction, sparks and not very stable. Detonations create "pushing power" where large objects are moved rather than shattered. Large pieces of the devise will be found and high amounts of residue remaining after the explosion.
        - Smokeless powder (Gun Powder)
        - ANFO: Ammonium Nitrate and 6% Fuel Oil
    - **High Explosives**: Decompose at a much faster rate. Generate shattering power, produce smaller and sharper fragments, and generally don't leave residue. They can be further divided into small subgroups:

  - **Primary Explosives**: Shock and/or heat sensitive and used as primers that ignite secondary high explosives. Example: primers in ammunition and blasting caps.
  - **Secondary Explosives**: More stable and are usually detonated by the shock generated from a primary explosive.
- **Alfred Nobel:** In 1847 nitroglycerin was invented. It was unstable and dangerous to handle. Nobel combined it with diatomaceous earth (DE), also known as dynamite. It was now stable and easy to handle.

Chapter 12 Review Questions:

1. **What is fire**? It has frequently been defined as the rapid oxidation process with the evolution of heat and light.

2. **What is meant by the term incendiary fire**? Fire intentionally caused by human activity.

3. **What is the area of origin**? Fire-related area in space where a fire started. It will extend horizontally and vertically and follow the path of least resistance through ceilings, doorways, window openings and stairwells as it progresses unimpeded.

4. **What is the point of origin**? To properly identify the cause of the fire, it is necessary to examine all potential ignition sources at the point of origin. The area where the fire damage is the heaviest, will ultimately identify the area or areas of fire origin. The absence or present of contents, the condition of the contents, and the fire spread as determined by various char, heat and smoke patterns further help to evaluate the ultimate point of origin of the fire.

5. **In this context, what is meant by the cause of the fire?**
   a. Accidental, explainable (may include negligent acts)
   b. Natural, act of nature (lightning)
   c. Incendiary, intentional act of setting a fire
   d. Undetermined, cause unknown, unable to identify

6. **What techniques can be used to identify the victim of a fatal fire**? Gross identification can be done if body is not too damaged. This is done by a family/friend coming in and doing a visual ID. Others are done by fingerprint comparison, odontology, a physical examination for tattoos or scars, surgical procedures, deformity, personal papers, jewelry, clothing, size and stature.

7. **List some common accelerants. Which is most common and why**? Accelerants can be solids, liquids, or gases, with gasoline being the most commonly used.

8. **What is detonation and how is it different than a flame**? A detonation is actually not burning in the sense that you think. Rather than being started by a match or flame, a detonation is initiated by pressure. A byproduct of the blast effect is an extremely loud noise created by the pressure wave.

Chapter 13: Fingerprints

- Fingerprints along with DNA and dental remains are important in making unequivocal identification of human remains.
- Fingerprints are also a member of a class of biometric identifiers that would also include: retina or iris patterns, face thermography.
- The two features of fingerprints that are the most important for their means of identification are:
    - Unique
    - Permanent
- A person's genetic make-up probably plays a part in determining the sizes and basic shapes of the patterns and ridges, but it is not the only factor. We know this because identical twins have different patterns.
- **Sir William Herschel**: First European to recognize the value of fingerprints as a means of personal identification. Demonstrated the persistence of the ridge patterns.
- **Dr. Henry Faulds**: Around 1880 noted that fingerprints could be classified and that ridge detail is unique. Mentioned apprehending criminals by locating fingerprints at scenes.
- **Juan Vucetich**: Considered the Western Hemisphere's fingerprint pioneer. Wrote a book on the subject in 1894. The first recorded case in which fingerprints were used took place in Argentina. He came up with a classification system for fingerprints that was/is used in Argentina and throughout South America.
- Rojas murder in Argentina solved by bloody fingerprint.
- Jennings case in America considered a landmark fingerprint case in the courts 1910 (Chicago).
- AFIS = Automated Fingerprint Identification System. There are two primary applications for this system:
    - Searching large files for the presence of a ten-print set of prints
    - Searching large files for single prints.
- AFIS databases hold two types of files for profiles:
    - The knowns; prints of known individuals
    - The forensic file or database; images or profiles from unsolved cases.
- IAFIS = Integrated Automated Fingerprint Identification System: A national criminal database maintained by the FBI of all of the 10-print cards received from all over the country.
- Three types of Fingerprints:
    - Patent
    - Plastic
    - Latent
- Processing Latent Prints:
    - Development
    - Enhancement
    - Visualization
- Sweat Glands:

  - Eccrine
  - Apocrine
- Most methods for development of latent prints were developed based on knowledge of the latent print residue composition. The methods commonly used can be broadly divided into three groups:
  - Physical
  - Chemical
  - Special Illumination
  - Combination of all three
- Fingerprints developed ***in situ*** at a scene must be photographed prior to any lifting/collection efforts.
- Elemental iodine is one of the compounds in nature that sublimes; that is, it can pass from solid to vapor without becoming liquid. It probably reacts with the lipid components in the print residue.
- Chemical methods for rendering iodine prints a permanent color that will not fade. One is using a starch solution.
- **Ninhydrin**: Reacts with amino acids forming an adduct called Ruhemann's purple. Ninhydrin has also been analogue to form DFO.
- **Physical Developer**: Reacts with the lipid and other water-insoluble components.
- Latent prints may also be viewed under alternative light (525 nm) or laser illumination. Normal white lite wavelengths is about 300-800 nm.
- Fingerprint identification rests on 4 premises:
  - Friction ridges develop during fetal growth before birth in their definitive form.
  - Friction ridges remain unchanged throughout life with the exception of permanent scars.
  - The friction ridge patterns and their details are unique and not repeated.
  - The ridge patterns vary within certain boundaries, with allow the patterns to be classified.

Chapter 13 Review Questions

1. **What is the primary value of fingerprints as evidence**? They are one of the oldest and most important in all of the forensic sciences. They can be used as a means of personal identification. They are unique to an individual and persistent unless the dermal layer is damaged.

2. **What are biometric identifiers? How are fingerprints related to biometric identifiers?** Biometric identifiers include retina or iris patterns, face thermography, and some others. Fingerprints may be thought of as one member of this class. They can be used as a means of personal identification.

3. **What is friction ridge skin? Where is it found on the human body**? It is found on the palms and soles of the feet. It is a complicated pattern of ridges. Assist in preventing slipping on the feet and being able to grasp things in the hands.

4. **Who were Herschel, Faulds, Vucetich, and Henry? Describe their contributions to fingerprint science**.
    a. Herschel: First European to recognize the value of fingerprints as a means of personal identification. Demonstrated persistence of the ridge patterns in his own prints taken over 50 years.
    b. Faulds: Noted that fingerprints could be classified and that ridge detail is unique. Using fingerprints as a means of identifying criminals.
    c. Vucetich: Western Hemisphere's fingerprint pioneer. Value of fingerprints as a means of criminal identification. Came up with a fingerprint classification system that is used today in South American countries.
    d. Henry: Came up with a fingerprint classification system that is still used today. This enabled efficient searching of large files.

5. **What is AFIS? Indicate what the letters stand for, describe the system, and explain how it helps in fingerprint identification**. Automated Fingerprint Identification System. It is a computer storage and retrieval system for fingerprints originally developed for law enforcement application. There are two principal applications. The first is searching large files for the presence of a ten-print set of prints. The second is searching large files for single prints, usually develop latent print from crime scene.

6. **What are the three main types of fingerprints that can be found at a scene**? Patent, Plastic and Latent.

7. **What is meant by "development" or "enhancement" of a latent fingerprint**?
    a. Development = A process applied to a latent fingerprint to make it visible.
    b. Enhancement = Rendering an impression more visible through physical, photographic, chemical or digital methods.

8. **What is an example of a physical method for enhancing latent fingerprints**? Applying fine particles to the fingerprint residue where it adheres preferentially, thus creating contrast between the ridges and the background. Powdering and SPR are examples.

9. **What is an example of a chemical method for enhancing latent fingerprints**? Any application of a chemical to enhance a latent print. Ninhydrin, DFO, Cyanoacrylate, etc.

10. **Explain how you could use a laser in latent fingerprint enhancement**. A laser is also a very high-intensity light source, but it emits light of a single wavelength (monochromatic light). Run the light of the laser over the surface you're looking at and see if any latent prints become visible. You can also use it after it has been chemically treated.

11. **How can a bloody fingerprint be enhanced**? They can be enhanced chemically. You just have to make sure that there is a fixodent in the mixture or the print will be ruined. After you spray, dip, wash, the chemical onto the bloody print, you will rinse it and possibly re-apply. The prints become fixed to the surface and there will be a color change. It is best to use a color that will show contrast to the surface the print is located on.

12. **What are systematic approaches to latent fingerprint enhancement**? The idea is to apply latent development techniques in a way that maximizes the number of identifiable prints. The least destructive technique is applied first, and techniques are generally applied in a sequence that allows the maximum number to be used if necessary. Systematic approaches vary according to the surface or substratum on which the latent is located. Porous surfaces, such as paper, for example, call for a different set of techniques applied in a different sequence than nonporous surfaces.

13. **What steps and principles are involved in fingerprint identification**? Fingerprint examiners are generally extensively trained and required to accumulate significant experience before being entrusted with the responsibility of making identifications. Prints need to be looked at and determined if there is sufficient detail for a comparison/identification. If yes it will be compared to a known print/card. This process is reliable due to four basic premises:
    a. Friction ridges develop during fetal growth before birth in their definitive form.
    b. Friction ridges remain unchanged throughout life with the exception of permanent scars.
    c. The friction ridge patterns and their details are unique and not repeated.
    d. The ridge patterns vary within certain boundaries, which allow the patterns to be classified.

14. **What does "ACE-V" mean**?
    a. Analysis: Determine its proper orientation, decide if there are any color reversals or other unusual circumstances, decide suitability, and then proceed to the next step.
    b. Comparison: it takes place at several levels. The overall pattern and ridge flow are first examined. Then the individual minutiae are compared as to type of features and their locations. Finally the pore shape, locations, numbers and relationships as well as edge features are examined.
    c. Evaluation: Eliminate or identification.
    d. Verification: Peer reviewed by a second latent print examiner. Making sure that all of the findings were correct.


Muzzle
Front sight
Slide
Decocking/
safety lever
Hammer
Serial number
Trigger
Grip

Chapter 14: Firearms and Tool Marks

- **Handgun**: There are two types:
  - Revolver
  - Automatic and Semi-Automatic pistols
- **Automatic and Semiautomatic** weapons function in one of three ways:
  - Blowback
  - Recoil
  - Gas piston
- **Blowback**: The fired cartridge pushes the breechblock backward against a spring. The expended cartridge is extracted by the moving breechblock and ejected from the weapon. The compressed spring then pushes the breechblock forward, removing a cartridge from the magazine and inserting it into the firing chamber.
- **Recoil:** In the recoil operating system, the barrel of the weapon and its breechblock recoil a short distance together; the breechblock then unlocks from the barrel and continues to recoil rearward against the spring. The compressed spring returns the breechblock to its original position, loading a fresh cartridge into the firing chamber.
- **Gas-piston**: A small amount of the propellant gases passes through a small hole in the barrel into a gas piston. The expanding gas forces the piston to the rear; a rod connects the piston to the breechblock so that the breechblock is also pushed to the rear.
- **Revolver**: The cartridges are held in firing chambers in a rotating cylinder.
  - Single-action revolvers are fired by manually cocking the hammer and then pulling the trigger. Cocking the hammer both rotates the cylinder to place one of the chambers under the hammer and cocks the firing mechanism.
  - Double-action revolvers are fired by a long trigger pull that raises the hammer, indexes a firing chamber under the hammer, and then allows the hammer to drop, firing the cartridge.
- **Semi-Automatic**: These weapons are also referred to as autoloaders or self-loaders; laypersons sometimes incorrectly refer to these weapons as automatic pistols. The cartridges are held in a magazine (usually removable) and are loaded sequentially into the pistol from the top of the magazine. The typical firing sequence is as follows:
  - A cartridge is chambered in the pistol, usually by manually moving the slide or breechblock to the rear, then allowing it to move forward and strip the top cartridge from the magazine; simultaneously, the firing mechanism is cocked.
  - The shooter pulls the trigger, firing the cartridge.
  - Some of the energy produced by the fired cartridge is used to move the slide or breechblock to the rear, extracting the spent cartridge from the chamber, ejecting it from the weapon, and cocking the firing mechanism.
  - A spring compressed by the rearward travel of the slide or breechblock pushes the slide or breechblock forward, stripping an unfired cartridge from the magazine and loading it into the firing chamber. At the end of this cycle, the pistol is left loaded and cocked; it requires only the pull of the trigger to fire another shot.
- **Rifle**: Designed to be held in two hands when fired from the shoulder. Four main types:
  - Lever Action

  - Pump Action
  - Bolt Action (developed to shoot more powerful cartridges)
  - Semi-Automatic Rifles
- **Assault Rifle**: Automatic weapons that fire a reduced-charge rifle cartridge. Example: M16, AK47
- **Rifling**: System of spiral lands and grooves cut into the interior of a gun barrel; imparts rotation to fired bullets, improving their accuracy.
- **Lapping**: After the rifling has been cut, the interior of the barrel may be polished (lapping): a soft metal plug is cast inside the barrel and then pushed up and down with rouge (a powder used to polish metal). To remove imperfections.
- The most modern mass-produced firearms are rifled by:
  - Broaching
  - Swaging
  - Hammer Forging
  - Electrochemical Etching
- **Broaching** a rifle barrel:
  - Drilled out to approx. desired bore diameter
  - Reamed to remove drill marks
  - Gang broach (long rod having cutting tools) is forced through barrel
  - Multiple gang broaches used each slightly larger until cut to the right depth
- **Swaging** a rifle barrel:
  - Drill to a specific diameter
  - Reamed to remove drill marks
  - Swaged. Rifling button forced through barrel engraving the rifling pattern expanding the bore to the desired size.
- **Hammer-Forged**:
  - Barrel drilled out to a larger diameter bore than wanted.
  - Steel mandrel is inserted and barrel is hammered down on the mandrel
  - The mandrel is then knocked out of the barrel
  - Used to produce barrels with **polygonal rifling** (Glock)
- **Electrochemical Etching**:
  - Barrel drilled out and interior surface is coated with strips of chemically resistant polymer.
  - Voltage is applied to the barrel and grooves etched out.
- **Cut Rifling**: Rifling that is produced by hook cutting, scrape cutting and broaching. Cut rifling tends to leave more forensically useful markings inside the rifled barrel than the other methods.
- **Caliber**: The size of a firearm barrel; the diameter (cm/mm) of a circle that is tangent with the top of the lands of the rifling. Calibers are merely nominal. The actual bore diameter may be different.
- Cartridge Cases will be marked by a number of firearm components:
  - Firing pins
  - Breechblock

  - Backing plate
  - Extractors
  - Ejectors
- **Choke Muzzle**: A unique feature of shotgun barrels. It is commonly a constriction in the muzzle that serves to concentrate the shot pattern.
- **Four (4) degrees of Choke**:
  - Full Choke (greatest)
  - Modified Choke
  - Improved Cylinder
  - Cylinder-Bore (no choke at all)
- If barrel has been sawed off, metal burrs may be left at the muzzle. These will mark shot, wads, or shot columns in a unique fashion.
- **Gauge:** The diameter of shotgun barrels are designated as gauge. Is defined as the number of spherical lead balls having the diameter of the interior of the barrel that weigh one pound.
- **Bullets**: Can be made out of many different components/metals;
  - **Lead Bullets**: Soft and readily deformable. Used in low velocity bullets because the surface can be easily stripped off by the rifling. Lead is a ductile/malleable metal so they are easily marked by rifling. Will undergo extreme deformation or even fragmentation.
  - **Lead Alloy Bullets**: Contain a small % of an alloying element such as antimony or tin. They are harder than lead and are consequently used in weapons that have a higher muzzle velocity. Will be marked by the weapons rifling and readily deform on impact. May be plated with thin coating of copper.
  - **Semi-Jacketed Bullets**: Commonly consist of a lead core covered with a thin jacket of brass around the sides leaving nose exposed (hollow point bullets).
  - **Soft-Point Bullets**: Semi jacketed with a soft metal plug in the nose. This expands when bullets enter big animals. Used mainly for hunting.
  - **Explosive Bullets**: Percussion caps in the hollowed out noses of a hollow point bullet. When the bullet enters the body the bullets separate from the lead cores. Recover the jacket because it is the only thing with the weapons rifling.
  - **Full Metal Jacket**: Lead core covered with a brass jacket. Not well marked by the rifling.
  - **Teflon-Coated Bullets**: Self-lubricating property of Teflon reduces the friction between the bullet and the barrel of the weapon and allows the bullet to reach a very high muzzle velocity. Due to this velocity they can penetrate an engine block and Kevlar.
  - **Frangible Bullets and Open Tubular Rounds**: Consist of iron or copper particles; they particles are pressed together or held together with an organic binder. They are used in shooting galleries and for killing livestock in slaughterhouses.
  - **Wadcutter Bullets**: Flat-nosed cylindrical bullets used for target shooting.
  - **Hollow-Point**: Depressions in their noses; it facilitates expansion of bullets when they enter tissue.

- **Cannelures**: Knurled grooves engraved around the circumference of bullets. They may contain lubricant, and the mouth of the cartridge may also be crimped into the bullet's cannelure to hold the bullet in the cartridge. Cannelures in cartridges prevent the bullet from being accidentally pushed into the casing.
- Cartridges may be either be:
    - **Rimfire**: Have the primer composition in the rolled rim of the cartridge. Fired by hitting the rim.
    - **Centerfire**: Produced in a wide range of shapes. The cartridge is fired by hitting the head center of the cartridge.
- **Shot**: The most common type of projectile used by shotguns. They can be made of lead, lead alloy (chilled shot), or steel.
- **Wad:** Plastic or fiber disk that separates the shot in the shotshell from the powder in shotgun shells. It keeps the shot away from the sides of the barrel so that it shoots more accurately as well as holds the shot together so that they don't disperse to soon after leaving the barrel.
- **Headstamp**: The base of a cartridge/shotshell that bears information such as:
    - Vendor of the ammunition
    - Gauge/caliber
    - Logo
- **Smokeless Powders**: Are produced by one of two processes: the Extruded Powder or the Ball Powder process.
    - Single Base: Nitrocellulose
    - Double Base: Nitrocellulose and Nitroglycerin
    - Triple Base: Nitrocellulose, Nitroglycerin, and Nitroguanidine (propellants in artillery ammunition).
- **Stabilizers**: Reacts with the acidic breakdown products of nitrocellulose and nitroglycerin.
- **Flash Suppressants**: Interrupt the free-radical chain reactions in the muzzle gases. May be present within the powder particles or coated on them. May also be added to smokeless powder as a separate particle.
- **Deterrents**: Are coatings on propellant grains that reduce their initial burning rate. The reduction in the initial burning rate broadens the pressure peak and increases the muzzle velocity.
- **Opacifiers:** Prevent radiant energy from penetrating the surface of the powder grains (and initiating burning within the grains). **Carbon black is the most commonly used opacifier**.
- **Graphite Glaze**: Reduces sensitivity to static electricity, improves the flow of powder grains, and improves the packing density of the powder.
- The surface area of the powder grains is the major control factor that the manufacturer uses to adjust the performance of a smokeless-powder product.
- Only rubber-coated or heavily taped tools should be used either to probe for bullets or to extract them.
- Bullets may pick up textile fibers, traces of paint, or bits of concrete and brick from intermediate targets. Bullets may acquire patterned markings from clothing or window screens.

- General Rifling Characteristics to be determined are:
  - Caliber
  - Number of Lands and Grooves
  - Direction of Twist of the Rifling
  - Degree of Twist of the Rifling
  - Widths of Lands and Grooves
- Class characteristics of firearms can be determined from expended cartridges:
  - Caliber
  - Shape of firing chamber
  - Location of the firing pin
  - Size and shape of the firing pin
  - Geometrical relationship of the extractor and ejector
- **Skid Marks**: Are parallel to the axis of the bullet made when the bullet initially enters the rifling; the edges and surfaces of the lands will scrape along the bullet surface before the bullet is full griped by the rifling.
- **Forcing Cone**: Is a flare at the breech end of a revolver barrel that is intended to guide the bullet into the rifling. Hard to reproduce.
- **Slippage Marks**: Are made on a bullet when it slips along the tops of the lands without being gripped by the rifling. They are the result of the barrel being worn or having been bored out. They may also result if a sub-caliber bullet is fired in a weapon. They are hard to replicate.
- **Firing Pin Impressions and Breech Block Markings aka Bolt-Face Signatures**: Should be compared first because they can only be produced by firing a cartridge in a firearm.
- **NIBIN: National Integrated Ballistic Information Network**; Developed to facilitate linking firearms evidence in cases in different jurisdictions. Can and digitally capture images of bullets and cartridge cases.
- Many firearms have both Passive and Active Safety Devices. Some firearms have no safety devices.
  - **Passive Safety Devices**: Are features that the shooter does not have to set.
    - **Half-Cock Position**: Is intended to prevent the hammer from accidentally falling far enough to discharge the weapon. If the hammer is released before it is fully cocked, it will fall to the half-cock position and be stopped.
    - **Grip Safety**: Is located on the back of the grip of the handgun. It prevents the trigger of the weapon from being squeezed unless the heel of the hand has depressed the safety.
    - **Firing Pin Catch/Block**: Prevents the firing pin from moving forward to strike the cartridge primer until the trigger has been squeezed. This prevents the weapon from accidentally discharging if it is dropped.
  - **Active Safety Devices**: Are set by the shooter.
    - **Trigger Block**: Prevents the trigger from being squeezed.
    - **Slide Block**: Prevents the slide of a semiautomatic handgun from being drawn to the rear and also block the trigger mechanism.

    - **Safety Decocking Lever**: Prevents the trigger from being squeezed and rotates the rear section of a two-part firing pin so that the hammer cannot strike it. When the safety decocking lever is set, the cocked hammer of the weapon can be lowered without risk of an accidental discharge.
- **Serial Number Restoration**: When a serial number is stamped into a metal, the structure of the metal below the stamp is compressed and the structure is weakened.
- **Electrochemical Etching and Ultrasonic Cavitation:** Ultrasonic works on a principal similar that of chemical and electrochemical etching.
- **Bullet Ballistics**:
    - **Interior Ballistics**: Where the chemical energy stored in the propellant is converted into the kinetic energy of the projectile.
    - **Transitional Ballistics**: The projectile passes as it moves from interior ballistics to exterior ballistics. A spinning projectile experiences both lateral and vertical jumps. They are negligible in small arms.
    - **Exterior Ballistics**: The projectile moves under the combined effects of a number of forces such as gravity, centrifugal forces and aerodynamic forces.
- **Gunshot Residue**: Consists of particles from the gun barrel, particles from the bullet surface (lead, lead alloy, or brass), particles originating from the propellant (unburned or partially burned particles of smokeless powder as well as soot), and particles originating from the primer (lead, or lead, antimony and barium. Travels in a conical cloud in the direction of the target. Particles experience aerodynamic drag forces. Smaller drop out first, larger travel further.
- Forensic pathologists distance determinations:
    - Distant Shots
    - Close-Range Shots
    - Near-Contact Shots
    - Contact Shots
- **Distant Shots**: No detectable gunshot residue reaches the skin, clothing of the victim. The wound consists of a circular or elliptical defect in the skin which is surrounded by a marginal abrasion or contusion ring where the skin has been stretched and torn by the entry of the bullet. The marginal abrasion maybe overlaid by a gray ring (aka bullet wipe) which is propellant combustion products.
- **Close-Range Shots**: Gunshot reside will reach skin or clothing of the victim. Stippling or soot will be present. Closer the range, the more concentrated the stippling and soot.
- **Near-Contact Shots**: Stippling and soot are concentrated in a tight circle. Muzzle flash may tear clothing and char or melt clothing fibers. Hair on the body will be singed.
- **Contact Shots**: If done over bony plates like skull you will see **Stellate Defect**; an irregular, blown-out entrance wound. This is caused by the propellant gases separating the soft tissue from the bone creating a temporary pocket of gas which tears the skin. Blow back into muzzle of the gun is possible.
- Using ammunition from the same lot, ensures that critical components, such as primers and propellants, are the same for the questioned powder patterns and the test-fired patterns.

- Infrared imaging technologies have proven to be useful for visualizing gunshot residue patterns obscured by blood. Graphite-coated propellant particles and soot strongly absorb infrared radiation.
- **Griess Test, Maiti Test, Sodium Rhodizonate Test**: All used to detect gunshot residue patterns. Nitrate is detected on Griess and Maiti. Lead for Rhodizonate.
- Rule of Thumb: Shot gun pellets spread 1 inch laterally for each yard down range.
- Full-Choke barrels fire smaller, denser pellet patterns than cylinder bored barrels.
- Barrel inserts can be used to adjust the barrels choke.
- Sawing off a shotgun may increase the size of the pellet patterns it will fire; however, this phenomenon depends on the type of shotshells fired.
- If the mass of shotgun pellets encounters a target that slows down the leading pellets in the mass, the trailing pellets will overtake and collide with them.
- **Ricochets**: Can occur from any surface including water. There is a critical angle of incident below which bullets will ricochet from the surface. For most surfaces this angle is around 5-6 degrees. Bullet shape and composition also affect whether ricochet will occur.
- **Three (3) categories of Tool Marks**:
  - **Compression**: Individual characteristics more difficult to discern.
  - **Sliding**: Class characteristics more difficult to discern.
  - **Cutting**: Combination of both compression and sliding.
- Raw wood and hard metal are poor substrates for tool marks.

Chapter 14 Review Questions

1. **What general rifling characteristics of a firearm can be determined from a fired bullet**?
   Lands and Grooves.

2. **In what ways can the caliber of a firearm be determined from a fired bullet?** If the bullet is not deformed, its diameter can be measured with a micrometer, or it can be compared with bullets fired from weapons whose caliber is known. If the bullet is severely deformed, its possible caliber may be determined by weighing it. The weight of the bullet will rarely pinpoint its caliber but will serve to eliminate a number of calibers from consideration. If the bullet is fragmented, its possible caliber can be determined by combining the measured width of a land marking with that of an adjacent groove. The degree of twist of the rifling and the widths of the lands and grooves can be determined by microscopic measurements of the rifling marks on the bullets.

3. **What class characteristics of a firearm can be determined from an expended cartridge**?
   a. Caliber
   b. Shape of firing chamber
   c. Location of the firing pin
   d. Size and shape of the firing pin
   e. Size of extractors and ejectors (if any)
   f. Geometrical relationship of the extractor and ejector

4. **What markings on fired bullets are compared microscopically**? A distinctive pattern of parallel Striations.

5. **What markings on fired cartridges are compared microscopically**? Firing pin, breechblock, extractor, and ejector marks. Chambering, magazine marks.

6. **What conclusions can a firearms examiner reach as result of a microscopic comparison of bullets or cartridges**? Positive Identification, Negative Identification, Inconclusive.

7. **How is the range of fire estimated from a powder pattern**? Determination of the range of fire from a gunshot residue pattern requires the original powder pattern, the firearm used to fire the pattern, ammunition from the same lot as that used to fire the pattern, and knowledge of the weather conditions at the time of the shooting. Forensic pathologists usually place the range from which a gunshot wound was inflicted into one of several categories:
    a. Distant Shots: Are fired from such a range that no detectable gunshot residue reaches the skin or clothing of the victim.
    b. Close-Range Shots: Are inflicted at ranges short enough for gunshot residue to reach the skin or clothing of the victim. Two types will be seen. Stippling and Soot (smudging).
    c. Near-Contact Shots: Stippling and smudging are concentrated in a tight circle.
    d. Contact Shots: Most of the powder goes into the wound. Will have some smudge and stippling near the entrance wound area.

8. **How can the range of fire be estimated from a shotgun pellet pattern**? When a shotgun is fired, the pellet mass spreads laterally. Thus, pellet patterns fired at different ranges have different sizes and different shot densities. In order to determine the range of fire from a shotgun pellet pattern, the firearms examiner needs the original pellet pattern, the shotgun used to fire the pattern, ammunition from the same lot as that used to fire the pellet pattern, and a knowledge of the weather conditions at the time of the shooting.

9. **What are the three types of tool marks**?
    a. Compression (indented) Tool Marks: Results when a tool is pressed into a softer material. Such marks often show the outline of the working surface of the tool, so class characteristics of the tool can be determined. Individual characteristics are harder to discern.
    b. Sliding Tool Marks: are created when a tool slides along a surface; such marks usually consist of a pattern of parallel striations. Harder to detect class characteristics.
    c. Cutting Tool Marks: Indents the material being cut and, as it does so, the working surfaces of the tool slide over the cut surface.

10. **How should tool marks be processed at the scene of a crime**? No attempts to fit a suspect tool into a tool mark should be made. To do so risks alteration of the mark and would vitiate the value of any transferred trace evidence on the tool. Documentation should be done in the usual manner, with notes, sketches and photographs. The tool mark evidence should be collected and transported to the lab for comparison. If it cannot be transported a cast of the tool mark should be made.

11. **What conclusions can a firearms examiner reach as result of a microscopic comparison of tool marks**? Positive Identification, Negative Identification and Inconclusive.

12. **The energetic material in single-base smokeless powder i**s Nitrocellulose; the **energetic materials in double-base smokeless powders are** Nitrocellulose and Nitroglycerin.

13. **In a rifled gun barrel the raised areas are called** Lands, **and the recessed areas are called** Grooves.

14. **Cut rifling methods are** Hook Cutting, Scrape Cutting, and Broaching.

15. **Barrels with polygonal rifling are made by** Hammer Forging.

16. **The two types of metallic cartridge priming systems** are Center Fire and Rim Fire.

17. Markings made on the bases of cartridges by breech blocks are also called _____.

18. **Three commonly used chemical methods for the visualization of powder patterns produced by ammunition having lead-based primers are** Griess Test, Maiti Test, and Sodium Rhodizonate Test.

19. _____ reagent is used for visualization of powder patterns fired with ammunition containing lead-free primers.

20. **An irregular, blown-out entrance wound in the skull is termed** a Stellate Defect.

21. **The ring of bullet lubricant, gunpowder combustion products, and metal from the bullet surface surrounding a gunshot wound is called** Gray Ring.

22. Negative Moulage, Low-Melting Metal Alloys, and Silicone Rubber **have been used to make casts of tool marks.**

Chapter 15: Tread Impressions

- **Tire Tracks**: Relative dimensions between two or more tires of a vehicle; determine track width, wheel base, and turning diameter.
- **Sidewall labeling**: Each tire has two sides; label side (exterior), and serial side (interior). Tire information on the sidewalls will give date, month, plant the tire was manufactured as well as size and brand name.
- Tire track width, wheelbase, turning diameter and the relative position of multiple turning tracks are collectively referred to as tire track evidence.
- **Tire Track Width (Stance):** The measurement made from the center of one wheel to the opposite wheel or impression.
- **Wheelbase:** The measurement between the centers of the hubs of the front wheels to the centers of the hubs of the rear wheels.
- **Turning Diameter**: The diameter of the circle a vehicle makes when it's steering when it is fully turned; front wheels only.

Chapter 15 Review Questions:

1. **How should a scale be properly used in photographing a shoe impression and why is it used**? The scale should be placed on the same level as the impression. It is placed there so that the photographs can later be scaled to size and a comparison can be completed. If the scale is not on the same level then the photograph will be off/distorted.

2. **What material is used to cast footwear impressions**? Dental Stone or any other strong gypsum product.

3. **Name and briefly describe four methods of enhancing footwear impressions**. Photography, adding powder, chemical enhancement, ESDL.

4. **What areas are examined in a footwear impression comparison**? The entire outsole and sometimes the sidewall/upper area depending on how deep a 3D impression is.

5. **What is the purpose of making known impressions of shoes during an examination**? To help the examiner see how certain characteristics are repeated during test impressions. They also help with exemplars and the comparison.

6. **Name three materials that can be used to lift a shoe impression that has been treated and enhanced with fingerprint powder on a nonporous tile floor, and indicate which one will make the most complete** lift. Gelatin lift, Fingerprint tape, Acetate Lift. Gelatin will give you the best lift.

7. **Some footwear impressions are latent or hardly visible. Do these impressions contain sufficient detail for examination**? Yes. Even better than most that have been powdered.

8. **What information can a shoe print provide in an investigation**? Name at least three. The sequence of events. The pathway through the scene. The number of suspects. Can back up a suspect's story or prove them wrong.

9. **State if a partial footwear impression can be examined and identified. Explain. Yes. The majority of the impressions found on scene are only partial impressions**. So they can and do get identifications. They just have to be found and submitted.

10. **Are class characteristics or individual characteristics normally used to eliminate a shoe**? Yes all the time.

11. **What four areas of the tread are involved in a forensic comparison**? Tread pattern, wear features, random individual characteristics, class characteristics. Tread dimension.

12. **What is "track width"? Explain how it is measured**. Also known as the stance. It is the measurement made from the center of one wheel or impression to the opposite wheel or impression. The measurements between the front and the rear tires will not be the same, they will be slightly different.

13. **Differentiate between a "tire impression" and "tire track."** Tire Tracks are the relative dimensions between two or more tires of a vehicle. Tire tracks reflect general information about the vehicle that left the impressions. By measuring the dimensions of the tire tracks at the crime scene, it may be possible to determine or approximate the track width, wheelbase, or turning diameter of the vehicle that created the impressions. Tire tracts can sometimes be used to profile the type or size of vehicle used and provide other information that could help to include or exclude a suspect vehicle. The Tire Impression is the two or three-dimensional impression left at a scene by the tire. It records the characteristics of the tread pattern on another substrate.

14. **What does the term "OE" tires mean, and what are "replacement tires"**? OEM Tires are the tires that come with the vehicle from the manufacturing plant. They are specific to certain vehicles. Replacement tires are tires that a person goes to a tire store and buys to replace the OEM tires.

15. **What is the "DOT" number on a tire, and what are two important pieces of information that it contains**? The DOT number is required to be on a tire. It contains important information such as: the plant code which indicates the exact location where the tire was made. The week and year the tire was made. If the tire was a retread tire. What type of vehicle the tire should be on, light truck, passenger etc. The aspect ratio number, if it is a radial tire. The rim diameter. Etc. All of this information will help in the narrowing down of possible vehicles that could have left an impression at the scene.

16. **What does the term "noise treatment" refer to**? To reduce the nose that tires emitted, the tire industry created tire designs that change the size (pitch) of the tread blocks around the tire, thus creating a variety of pitches. This and other engineering factors that help reduce the noise a tire generates are referred to in the industry as noise treatment.

17. **What are "tread wear indicators," and how often must they appear around a tire**? Also known as a wear bar, is a raised rubber bar that is 2/32 inch above the base of the tire grooves. The DOT requires that all tires over 12 inches in diameter contain a minimum of six treat wear indicators around the circumference of a tire. As the tire tread wears down to the height of 2/32 inch, the wear bars become very noticeable. The purpose is to indicate to the car's owner that the tire should be replaced.

18. **What is the Tread Design Guide, and how might it assist in an investigation with tire tread evidence**? It is a magazine that is published which provides photographs of most of the tires designs. Investigators can use it to like a tread design from a crime scene to a particular design and brand of tire.

19. **Should a cast be made of a three-dimensional tire impression, and if so, why**? Yes. A cast will provide an examiner with more information and will likely result in a far better examination result. To allow the examination to utilize the noise treatment of a tire fully, it is essential to cast long sections of each tire impression being recovered.

20. **Explain why it is important to document the positions of tire impressions at a crime scene, both photographically and otherwise**. Scenes that contain various tread designs are often complicated and sometimes difficult to evaluate at the scene. it is wise to take your time, approach the area cautiously, and take general scene photographs from may angles. After this has been done, additional examination quality photographs should be taken followed by casting of the tread impressions. This will enable the examiner to know what portion of the recovered/documented treads they are looking at as well as if a vehicle is found the location of all of the tires of the vehicle, especially if they are multiple different tires, can be shown to correlate to the position of the impressions found at the scene.

Chapter 16: Trace Evidence

- Trace evidence can literally be anything. There are **two types of transfer**:
  - **Primary Transfer**: Transfer of trace evidence from its original location to a different location.
  - **Secondary Transfer**: Transfer of trace evidence from a location that was not the original scene to another location.
- **Microanalysis:** Is the application of a microscope and microscopical techniques to the observation, collection, and analysis of micro-evidence that cannot be clearly observed or analyzed without such devices (milligram/microgram sizes).
- Analysis with a microscope may be limited to observations of morphology or involve the collection of more sophisticated analytical data, such as optical properties, molecular spectra, or elemental analysis.
- **Stereo Microscope**: Constructed from two similar but separate optical microscopes for observation by each eye simultaneously. Views separated by approximately 15°; generating a 3D image.
- **Compound Binocular Microscope**: Two eyepieces, however, both eyes see same image due to single common objective. This microscope often offers transmitted light; capable of magnifications of 25 to 1220x greater than the object. Total magnification (TM)=EPx (eye piece magnification) multiplied by OBJx (objective lens magnification).
- The total magnification of a microscope is computed by the power of the objective lens (OBJ) or first lens, multiplied by that of the eyepiece lens (EP) or final lens.
- **Micrometry**: A scale calibrated with a stage micrometer can be placed in the eyepiece lens (EP) of a microscope so that its image is superimposed on the view of the subject, thereby allowing evaluation of characteristics such as length, width and thickness.
- **Polarizing Light Microscope (PLM) aka Petrographic Microscope**: One of the most powerful analytical tools available to forensic science. Two polarizing elements are positioned in the optical path of the microscope. The elements are a polarizer and an analyzer.
- **Light:** A wave phenomenon. Characterized by velocity, wavelength, and frequency related to color; amplitude, brightness, and vibration direction.
- Normal light is randomly polarized. If the vibration is restricted to only one direction, it is referred to as **Plane Polarized Light**. Light can become partially or totally polarized in a number of ways, including reflection, adsorption, and propagation through an anisotropic material.
- **Crossed Polars**: A condition in polarized light microscopy in which the analyzer and polarizer are perpendicular to each other; results in extinction of transmitted illumination.
- **Birefringence:** Having two or more indices of refraction. When placed between polarizing filters, birefringent materials exhibit bands of color. The specific colors exhibited when white light is used are determined by the differences in the indices of refraction and the thickness of the birefringent material.
- **Michel-Levy Chart**: An analytical working tool that relates the birefringence, thickness, and retardation properties. Used in conjunction with polarizing light microscopy to inference colors.

- **Isotropic:** An isotropic material exhibits only one RI no matter which direction light propagates through the item or what the vibration direction is. Isotropic materials do not affect the vibration direction of light. Vacuums, gases, most liquid, amorphous solids, and isomorphic crystals are all isotropic.
- **Comparison Microscopes**: They are all similar in one design principle. They are in reality two microscopes linked by an optical bridge so the observer can simultaneously view two independent images in one field, each from a separate objective. Allows for superimposition of the two images.
- The lowest total magnifications are found on what are referred to as macroscopes.
- **Visible Microspectrophotometers (colorimeters)**: Lend themselves well to the accurate measurements of color by eliminating the subjectivity that is inevitable when a human observers and describes color.
- Microscopes equipped with colorimeters (visible spectrometers) operate in the range of the electromagnetic spectrum in which humans sense energy as color.
- **Infrared Microspectrophotometer**: Is a device that is capable of routinely collecting by transmission, reflection, or scattering measurements of the vibrational spectra on tiny samples that could never be analyzed using traditional infrared instrumentation. It is considered to be a form of Vibrational Spectroscopy.
- **Fingerprint Spectra**: Valuable sources of structural information leading to chemical classification, generic grouping, and specific identification in many cases.
- **Raman Spectroscopy**: A type of vibrational spectroscopy; trace evidence analysis by linking a microscope to a spectrometer. Based on how light from a source is scattered by the electron cloud of a molecule.
- **Scanning Electron Microscope (SEM)**: Permits the viewing of samples at much greater magnification and resolution than is possible by light microscopes. Magnification is possible in the range of 10 to 100,000 times.
- When the SEM is combined with an energy-dispersive x-ray spectrometer (EDS), the technique becomes even more powerful. It can show a particle smaller than 1 micrometer while generating spectra revealing the elemental composition of the object.
- **Glass:** Is a reasonably hard, transparent or translucent material composed of fused inorganic materials. Upon cooling, it is amorphous in nature, an isotropic. It will be made of a wide variety of chemical compositions depending on what it is being used for.
- **Conchoidal Lines**: Edge characteristics of glass fractures. They are stress marks shaped like arches that are perpendicular to one glass surface and curved nearly parallel to the opposite surface. The perpendicular surface faces the side where the crack originated. 4 R's
- **Radial Cracks**: Fractures that originate from the impact point and propagate away.
- **Concentric Cracks**: Fractures that circle around the impact point.
- Physical Properties of Glass that can be analyzed:
    - Thickness
    - Color
    - Uniformity
    - Curvature
    - Surface conditions like tinting

  - Soiling
  - Imperfections
- **Float Glass**: Manufactured by floating molten glass onto the surface of a bath of melted tin. When under a UV light the side that had been against the tin will fluoresces.
- The refractive Index of glass can be determined by suspension in oils. This is called the immersion method.
- **Becke Line**: A method utilized to determine the refractive index of materials such as glass. A microscope is focused on the sample and the focus is then raised. The distance between the sample and the microscope objective is increased. When this is done, a halo or brightness near the edge of the sample, the Becke line, will move into the matter of greater RI, whether it is the sample or the mounting medium.
- **Single-Variation Method**: The reflective index is determined by recording the match temperature and employing the calibrated dn/dt of the oil to calculate the RI of the sample.
- **Double-Variation Method**: Employs a heating stage to maintain oil temperature, and a monochrometer is employed to determine the match wavelength.
- **GRIM (Glass Refractive Index Measurement)**: An automated method for determining the refractive index of glass. Employs computer control of the heating stage and a video detector to determine the match point.
- Hairs and furs are principally composed of keratins, which are sulfur-containing proteins that are interlinked to form stable fibrils and pigment composed of melanin.
  - Proximal End = Root portion
  - Distal End = tip.
- Growth stages of hair:
  - **Anagen**: Growth
  - **Telogen:** Dormant
  - **Catagen**: Transition
- Hair Structure:
  - **Medulla = Center**. Usually amorphous and vacant of material. Appears dark when viewed microscopically. Can be continuous, discontinuous, or fragmentary or not visible at all.
    - Uniserial Ladders and Multiserial Ladders found in rabbit.
    - Lattices found in deer
    - Vacuolated or cellular
  - **Cortex = Inner Layer**. Contains many important microscopic features, such as pigment, tiny air pockets called cortical fusi and ovoid bodies which are especially important in human hair examination.
  - **Cuticle = Outermost Layer**. Consists of a layer of scales covering the shaft.
- Scale structure can be divided into three basic types:
  - Coronal or Crown Like scales that look like stacks of paper cups. Characteristics of very fine hairs. (rarely human)
  - Spinous or Petal-Like Scales: triangular in shape and usually protrude from shafts. (Non- human)
  - Imbricated or Flattened Scales: overlap like roof shingles. (Humans and animals).

- What hair can tell you:
  - Racial origin
  - Body location
- When associating a hair to a person examine:
  - Tip
  - Root
  - Diameter
  - Scales
  - Pigment
  - Medulla
  - Cortex
  - Artificial treatment
  - Damage
  - Vermin/disease
  - Method of cutting
- **Fibers**: Can be either; natural, manufactured, or synthetic. Also grouped as animal, vegetable or mineral. Can either be isotropic or anisotropic. Almost all isotropic fibers are made from glass. A few synthetic fibers appear to be isotropic because their bifringence is so small and the fibers are not very thick. Cross-sectional shape alone can aid in determining the manufacturer and the end use of the fiber, such as in clothing or carpets. When looking through the stereo microscope look for the following:
  - Size
  - Crimp
  - Color and luster
  - Possible cross-section
  - Damage
  - Soil
  - Debris
- **Paint**: Are applied for protective value, aesthetic purposes, or both. When they are received at the lab they are not pristine; they are subject to uncontrolled environmental and collection effects. There are three basic generic components:
  - **The Vehicle**: Is the binder that holds all of the components together and is usually of polymeric nature consisting of natural or synthetic resins. The binder can form a surface film in a number of ways:
    - **Lacquer**: When the film forms by the simple evaporation of the solvent system of the liquid.
    - **Enamel:** Film is formed by chemical cross-linkage of a number of its components.
  - **Pigments:** Supply paint with color, hue and saturation. Can be organic (green and blues) or inorganic (whites, yellows, and reds).
  - **Extenders**: Added to the paint to increase its solid content and thereby, its opacity and hiding ability.

- **Modifiers**: Affect the resultant film's durability, gloss, flexibility, hardness, resistance to UV radiation and other characteristics.
- **Soil:** A complex mixture of mineral, animal and vegetable origin at various levels of change and decay.
- **Pollens**: Can be readily identified by their morphology using light microscopy or SEM (Scanning Electron Microscope).
- In the analysis of soil, the more common minerals referred to as the light fraction are considered much less important than those of greater density. Separations are first conducted, and then the minerals are identified by colors, shapes, and optical properties such as RI values and bifringence.
- **Gunshot Residue (GSR):** Is a mixture of organic and inorganic materials originating from the projectile, cartridge case, propellant, and primer that emerge from the barrel and other openings of a firearm and are deposited on the hands, face, hair, or clothing of persons in close proximity to the weapon when it is discharged. Barium, antimony and lead.

Chapter 16 Review Questions;

1. **What characteristic separates microscopic evidence from other evidence**? The analysis with a microscope may be limited to observations of morphology or involve the collection of more sophisticated analytical data, such as optical properties, molecular spectra, or elemental analysis.

2. **What instrument is employed for the collection and first evaluation of small evidence**? Microanalysis is the application of a microscope and microscopical techniques to the observation, collection, and analysis of micro-evidence that cannot be clearly observed or analyzed without such devices.

3. **How is the total magnification of a microscope determined**? Total magnification is computed by the power of the objective lens, or first lens, multiplied by that of the eyepiece lens, or finial lens.

4. **What is the most important factor in determining the resolving power of a microscope**? The revelation of detail, in reality, is a function of the resolving power (RP) of the microscope, which is related to the numerical aperture (NA) of the microscope objective.

5. **What are the important factors for the reporting of refractive indices**? An isotropic material exhibits only on RI no matter which direction light propagates through the item or what the vibration direction is. Variations in conditions such as wavelength and temperature can influence the RI.

6. **What are the characteristics that firearms examiners evaluate to match a projectile to a weapon**? Striation marks.

7. **Explain plane polarized light.** Is obtained by the use of polymer films in which the molecules are very highly oriented and have been treated with a dye so that they almost totally absorb light vibrating in all but one direction. This single direction is called the privileged direction. A portion of the light in the privileged direction is also absorbed, but this loss of intensity is small in comparison to losses of other direction. These polymer filters are known as Polaroid filters or films. When two polarizers are placed in such a way that light passes through one and then the second and privileged directions of each are perpendicular, no light will emerge from the second. This condition is referred to as crossed polar and results in complete extinction of transmitted illumination.

8. **What determinations about a glass fracture can be made by macroscopic examination**? Examination of a broken window can reveal whether the impact that caused the fracture was a low velocity blunt trauma or a high velocity point trauma. It will show directionality, sequence, impact side.

9. **What are the three major portions of a hair or fur fiber**? Medulla, Cortex, Cuticle

10. **What is the value of visible microspectrophotometry for fiber comparisons**? Vibrational spectra are a powerful tool for the forensic scientist to employ for his analysis of drugs, paints, inks, fibers, minerals, and other substances.

11. **What information about a paint sample can be obtained by use of infrared microspectrophotometry**? The layer structure of a recovered paint chip including the color of each layer. Organic and inorganic materials or mixtures such as paint can be investigation. These spectra are referred to as fingerprint spectra and are valuable sources of structural information leading to chemical classification, generic grouping, and specific identification in many cases.

12. **What data are obtained from a paint sample by use of SEM/EDS**? Not only can the layer structure be further elucidated by the higher resolution and the atomic number contrast available, but also elemental analysis can be performed with the x-ray spectrometer attached to the instrument.

13. What fraction or type of mineral is of most value for soil comparison?

14. What is working distance and how does it vary with objective magnification?

15. How could one increase the magnification of a compound light microscope and not change the working distance?

16. **What stage of hair growth usually results in the loss of hair**? Catagen Stage

17. **What elements, when found in a spherical particle, are considered necessary to conclude that the particle is characteristic for a gunshot residue**? The brighter particles are analyzed for their elemental content by EDS, and those with particular compositions, especially if spherical, are classified as GSR or probable GSR.

Chapter 17: Questioned Documents

- **Document:** Is any fixed method of communication between on individual and another.
- **Questioned Document (QD)**: Is one that in its entirety or in part is suspect as to authenticity or origin. Includes:
    - Checks
    - Wills
    - Contracts
    - Typewritten letters
    - Dollar bill
    - Postage stamp
- **Albert S. Osborn (1858)**: Published Questioned Documents and set forth the basic principles that document examiners still utilize. Osborn's testimony was crucial during the Lindbergh trial.
- Forensic document examination can involve the comparison of handwriting and signatures, typewriters and printing devices, alterations and obliterations of documents, counterfeiting, photocopy manipulation, etc.
- **U.S. Secret Service 1862**: Established to combat counterfeiting currency. 1902 it changed to protecting the president
- **Copybook Styles:** Penmanship such as Palmer and Zaner-Bloser methods.
- Neuromuscular coordination and visual perception differ from one individual to another. Individuals may incorporate shortcuts from the copybook style or add an extra flair to their writing.
- By the late teenage years, a person's writing has matured to the point where his/her writing style is unique.
- Handwriting is an acquired skill that becomes ingrained; it is habitual as well as individualized. This individualization is a basic principle in document examination.
- If the investigator does not submit proper standards, then an examination may be limited in scope or may not occur at all.
- Compare like to like.
- A general rule is to duplicate as much as possible the same conditions that occurred when the questioned material was written. Items such as writing instruments, writing positions, type of paper, etc.
- **Two classes of writing standards are utilized for comparison purposes**:
    - **Non-Request Writing**: Also known as spontaneous or un-dictated writings. It is likely to reveal the normal writing habits of the individual.
    - **Requested Writing or dictated Exemplars**: Are standards written at the request, and usually in the presence, of the investigator or examiner. May allow for distortion, in an attempt to disguise the writing.
- Examiners compare side by side and even do microscopic examinations. Look at the most obvious first, like the slant, how the letters are formed.
- To account for variation in a person's writing, an examiner needs an adequate number of writing or signature standards to compare.

- **Two principles of document examination**:
  - No two individuals write exactly a like
  - No one person writes exactly the same way twice.
- An examiner looks for this pattern in the standards. He/she can then determine whether the questioned writing is within the range of a person's variation.
- Types of Fraudulent Writing:
  - **Freehand Simulations**: An attempt to draw the signature or writing of another person usually when working with a model signature. Indications of freehand:
    - Pen pressure
    - Connecting strokes
    - Line quality
    - Patching
    - Retouching
    - Blunt starts
    - Pen lifts
  - **Tracings:** Involves using an original signature or writing as a guide to produce a fraudulent document. Indications of a tracing include:
    - Guidelines
    - Indented impressions
    - Poor line quality
    - Uneven
    - Wavy
  - **Normal Hand Forgeries**: The individual does not attempt to copy the victim's signature or writing. The forger either writes the name in his or her own writing style or tries to distort it.
  - **Disguised Writing**: The individual attempts to alter their own writing to deny authorship later; alternate upper/lower case, size change, additional strokes.
- **Factors that can affect handwriting**:
  - Health of the writer
    - Stroke
    - Arthritis
    - Essential tremor
    - Senility
    - Alcohol
  - It is important for the examiner to receive written standards that are contemporaneous with the time the questioned document was written.
- **Video Spectral Comparison (VSC):** Comparison and differentiation of inks by analyzing the infrared reflection and luminescing qualities inherent to the ink. Ink can be observed to luminesce glow, be transparent or appear unchanged.
- **Thin-Layer Chromatography (TLC)**: The use of a solvent that travels through a porous medium to separate compounds based on their chemical affinity with the solvent and the medium. Usually used for ink comparisons rather than obliterations; ink is separated from the paper portion by almost microscopic needle "punches." Ink punches are placed into test

tube, ink is separated by a solvent, solvent solution is placed on glass TLC plates, ink spot solution separates into bands of color for comparison.

- **Electrostatic Detection Apparatus (ESDA)**: Recover indented writing; extremely sensitive and non-destructive; writing can be recovered three, four or even more pages below original writing. The document to be processed may need to be humidified slightly to help electrostatic charge; page is covered with cellophane; cellophane is pulled into firm contact with paper by vacuum; cellophane and paper are subjected to high-voltage static charge; black toner is cascaded over the cellophane; toner aligns with indentations in paper. It is extremely sensitive and non-destructive.
- **Photocopy and Photocopier Examination**: A machine may leave characteristics on the printed document such as:
  - Grabber marks
  - Paper edge depressions
  - Designs incorporated into specialized paper for specific machines
  - Paper type
  - Toner type
- **Trash Marks**: Made because of dirt, scratches and other extraneous marks on the surfaces of the drum, cover, glass plate, or camera lens of a photocopy machine.
- **Indication of spuriousness include**: (Spuriousness = fake/false/counterfeit/forged/fraudulent)
  - Misaligned typing
  - Different fonts
  - Font sizes
  - Misaligned preprinted matter
  - Incorrect vertical
  - Horizontal
  - Margin spacing
  - Shadowing in the joined areas
  - Disproportionate area sizes
- Paper examination usually are necessary when there is some question as to whether or not one or more pages have been added to a multipage document or if a document was created at the time it was purported to have been created.
- Paper is commonly made of wood or cotton materials. During its production, various sizings, fillers, and coating are added.
  - **Sizings:** Such as rosin, enable the paper to resist ink penetration
  - **Fillers:** Such as clay, calcium carbonate and titanium dioxide, improve the surface and color of the paper
  - **Coatings**: Are added to the paper to improve its appearance and printing properties.
- **Micrometer**: Display differences in thousands of an inch in paper size and thickness.
- Paper opacity, color and brightness are directly related to the chemical additives that were put into the paper during its manufacturing.
- **Watermarks**: Area of translucent design incorporated into the paper.

Chapter 17 Review Questions:

1. **Is it possible for a document examiner to tell the personality of an individual from his or her handwriting**? No

2. **Can you determine the sex and age of the writer from his or her handwriting**? No

3. **What is the difference between requested handwriting standards and non-requested standards**? Non-Requested or undictated writing, material written by the individual during the everyday course of business, is likely to reveal the normal writing habits of the individual. No circumstances call attention to or provide undue emphasis to the act of writing. The writer, unaware that the writing will be used as a standard for comparison, is not likely to alter his/her handwriting for the purpose of disguise. The disadvantage is having the non-request written material authenticated for court. Requested exemplars are standards written at the request, and usually in the presence, of the investigator or examiner. Their advantage is that they provide writing that is comparable to the questioned material, and authentication is easily accomplished. The inherent problem with the requested standards is that they call attention to the writing process. This may inhibit the writer because of nervousness or may allow the writer to attempt to distort his/her writing for the purpose of disguise.

4. **Explain the meaning of the term "class characteristics" in relation to handwriting.** Are writing attributes observed in a group of writers that are probably derived from a penmanship system they learned.

5. **Can a document examiner identify all types of writing**? No

6. **Name one of the methods of ink differentiation for similar appearing inks**. Slight change in shading or hue, within the questioned material. Secondary lines, indicative of alterations when present. UV and thin layer will show where the difference is.

7. **Name one of the methods for the recovery of indented writing**. ESDA

8. **What is a photocopy trash mark and how does it occur**? Are made because of dirt, scratches and other extraneous marks on the surface of the drum, cover, glass plate, or camera lens of a photocopy machine.

9. **What instrumentation is used to test paper thickness**? Micrometer. It displays differences in thousands of an inch in paper size and thickness.

Chapter 18: Forensic Engineering

- **Forensic Engineering:** The application of engineering and physics to legal matters. Vehicular accidents, structural collapse; tracing and determining consequences of delivering energy from one place to another.
- The study of collisions is based on a study of the energy involved and the consequences of this energy being moved and changed.
- **Laws of Thermodynamics**:
  - Energy cannot be created or destroyed; it can only be converted from one form into another. Energy is converted.
  - When energy is converted, the process is never 100% efficient. Some is always lost to other forms, most often heat.
- Chemical energy (CE) =Kinetic energy (KE) + other "lost" energy
- Example of "lost" energy= heat, light, friction
- Kinetic energy (KE) = ½ mass x volume^2
- **Three reasons vehicular death rates have been reduced (car accidents)**:
  - People wearing seatbelts
  - Reduction in drunk driving
  - Crashworthiness of cars
- **National Safety Council (NSC):** 23% of all crashes involve cell phone use.
- The two most important analytical tools used by engineers in vehicular accident evaluations are the:
  - The Laws of Conservation of Momentum
  - The Laws of Conservation of Energy
- A well prepared police accident report usually notes skid mark lengths, final vehicle position, initial travel direction, and point of impact. This is the information needed to solve the momentum and energy equations.
- Facts missed during the initial information gathering stage at the time of the accident can either make or break the court case years later.
- Post-accident changes to the vehicle should be noted and segregated from the analysis of the actual accident damage.
- By applying reverse descriptive geometry drafting techniques, it is sometimes possible to determine the dimensions of crush, impact area, and other accident parameters from photographs.
- **Irreversible Work:** Energy used for a specific process (brake pads, skidding, muzzle friction), that cannot be converted back into the kinetic energy that it once was. Braking, skidding, crushing, reduces the vehicle's kinetic energy to zero.
- **Skid Formula**: A formula used to determine how fast a car was traveling before the driver applied his/her brakes and initiated skidding.
  - E_{work} = (mass x acceleration gravity) x frictional coefficient x distance skidded
- The initial speed of a vehicle can be computed by accounting for all the irreversible work done by that vehicle to bring itself to a stop. Accurate results are obtained when all the ways in which the vehicle dissipated energy are accounted for.

- **Momentum:** Describes the state of motion of an object. (Mass of object x velocity). As long as there are no external forces being applied on the vehicles, during a collision the net momentum of the vehicles just prior to the collision is equal to the net momentum just after the collision.
- There are two basic types of collisions:
    - **Elastic Collision**: The deformation of each body obeys **Hooke's Law** (within certain limits, the deformation of a material is directly proportional to the applied force causing the deformation). The two bodies will return to the same shape after the collision.
    - **Plastic Collision**: The deformation in the contact zone of each body does not follow Hooke's Law. A significate portion of the deformation is permanent. Once dented and smashed, it stays dented and smashed.
- Rule Of Thumb: For an external noise to be perceived it should be at least three decibels higher in intensity than the ambient noise level.
- Width of someone's peripheral vision can be important.
- VIN Information:
    - Had a vehicle been brought to the dealership to have all recall items fixed
    - Maintenance had been done on vehicle by authorized dealership
    - Dealership the maintenance was done at
    - Had the vehicle been stolen or involved in previous accidents
- Driver identification:
    - Injury
    - DNA on air bag
    - DNA/hair on windshield
    - Seatbelt burns
- **Metallurgical Characteristics**: A hardness test will determine its approximate strength and provide information as to whether it has been heat treated. The type of fractures is also very important.
    - **Fatigue-Type Fractures**: Indicates that the part has been partially cracked for some time before the accident. Susceptible to failure.
    - **Shear Fracture/Tensile Fracture/Bending Fracture**: No indication of fatigue usually indicates that the part failed at the time of the accident, perhaps being damaged as part of the accident process. No visible rust, corrosion, or extensive discoloration due to exposure to exhaust fumes or oil.
- **"Bootleg" nuts and bolts**: Are components that display the markings of a high-strength component but are actually low-strength, cheap substitutes designed to bilk the buyer.
- Improper weld repairs may sometimes precipitate mechanical failure. The metallurgical changes in the base metal immediately next to the weldment, the heat affected zone (HAZ) is weaker and more susceptible to fatigue than the original base material. This can often be detected by a hardness test profile across the suspect weldment.
- Tires blamed for causing accidents:

  - **Tire under-inflation**. Causes bending stress on the tire wall which causes the carcass to heat up. This area will weaken and the blow out. The blow out will take place in the area of maximum bending.
- **Durometer**: Measurement device to determine the "hardness" of a tire; if a tire has been run underinflated, the durometer number of the heat-affected tire will be measurably lower than the areas not subjected to bending stress and heat.
- **Point of Impact (POI):** Is often the most contested issue with respect to the scene examination of the accident. It is the location where the accident took place. Most accurate method to find this location is to look for gouge marks or tire marks. A skid, rim mark, or other tire marks that suddenly deviates in a new direction can be a good indicator of the POI. Debris fields are unreliable.
- The accident avoidance strategy approach assumes that certain parties to the accident traveled at the legal speed and performed reasonably in all their actions including braking, turning, and accelerating.
- New cars are being equipped with black box recorders and GPS (global positioning systems). These devices can record a vehicle's speed and position vs. time for an entire trip.
- **Buildings**: Once a structure is erected, factors work together to bring the building down. These factors are:
  - Corrosion
  - Weather
  - Aging effects in materials
  - Original design mistakes
  - Abuse
  - Unexpected loads
  - External forces
- **Static Load**: Includes the basic weight of the building itself and its contents. It should not have excessive deflection and movements. The static load is often subdivided into two categories:
  - **Dead Loads**: Loads that never seem to change in a building such as the weight of the floors, walls, support, and roof.
  - **Live Loads:** Loads that can sometimes change due to weather, occupancy, or building use. (snow/ice, furniture, machinery etc.).
- **Dynamic Loads**: Are loads on a building that change during a relatively short period of time. They are repeatedly applied and released. Adds to the static loads that a building must be able to handle which means that a building, or certain parts of a building, must be made even stronger than is required to handle its static loads. Unexpected dynamic loads eat into a building's margin of safety. Wind, earthquakes, construction projects.
- **Margin of Safety**: Buildings are designed to support static loads that are several times stronger than what the designer anticipates would typically be needed. This is called the margin of safety.
- **Domino Effect Failure**: Like the trade towers. When one section gives, the pressure of the dropped load causes the next section to fail, and it continues on like dominos. If the domino effect is interrupted early, the consequential damage can be significantly mitigated.

- **Fire Load**: The amount of material that can burn.

Chapter 18 Review Questions:

1. **The death rate in automobile accidents has been halved in almost three decades. How was this done?** There are three primary reasons.
    a. More people are regularly wearing seat belts
    b. There has been a significant reduction in drunk driving
    c. Crashworthiness of cars and vehicles has improved.

2. A car skidded on a roadway that has a coefficient of friction with the road of 0.7. A police officer measured the skid marks and noted them to be 100 feet long. Two years later at a trial, the lawyer for the driver argues that the officer did not measure the skid marks correctly. He asserts, based on photographs, that the skid marks were no more than 92 feet long. Is the difference significant?

3. **Improper driving is consistently responsible for approximately two-thirds of all vehicular accidents. What are the three primary categories of improper driving that cause accidents?** Consistently through the years, the three most significant causes of improper driving have been:
    a. Excess speed
    b. Right of way
    c. Failure to yield

4. **If improper driving is responsible for approximately two-thirds of all vehicular accidents, what is responsible for the other one-third**? Accidents caused by alcohol and drugs.

5. **What are the two most important analytical tools that an engineer uses to evaluate a vehicular accident**? Conservation of Momentum and Conservation of Energy.

6. **In analyzing a vehicular accident, reliance on verifiable physical evidence should be primary. Give examples of verifiable physical evidence**. Usually includes
    a. tire and skid marks
    b. representational plan of the accident area
    c. location and depth of impact damage on the vehicles and other damaged items observed at the scene
    d. mechanical condition of the vehicles
    e. type and location of impact debris noted at the scene
    f. paint transfer marks and other vehicle to vehicle/object contact marks
    g. road conditions
    h. weather conditions
    i. physical and metal conditions of the driver

7. **In vehicular accident cases, eyewitness testimony is usually gathered and recorded. Explain why this type of evidence should be evaluated with caution**. Distance, lapsed time and speed are difficult to judge accurately even for an experienced observer. Drivers involved in the accident are notorious for underestimating their own speed and overestimating the speed of the other driver.

8. Alcohol decreases in a man's blood at a rate of about 0.017% per hour. Bill has an accident, and his blood alcohol level is checked about two hours after the accident at a local hospital. During that time he is in police custody and does not drink anything. The analysis determines that his blood alcohol at the time of testing is 0.05%. If the legal limit is 0.08%, was he legally drunk at the time of the accident?

9. Alcohol decreases in a woman's blood at a rate of about 0.015% per hour. Susan has been drinking and has a blood alcohol level of 0.10%, as determined by a breath analyzer administered by a barkeeper. Being a responsible driver, Susan does not want to drive while legally drunk. How long does she have to wait to have a blood alcohol of less than 0.08%?

10. **A car reportedly traveling at 70 mph is struck by another vehicle and immediately begins leaking radiator fluid. The spot where radiator fluid is first noted on the highway is called the point of impact by the officer at the scene. Prepare a scientific case explaining why this is a bogus call by the officer**. The fluid will take some amount of time before it hits the roadway. In that time the vehicle has traveled/moved. So the point of impact if it is determined by this area is wrong. The only way you could say an area is the point of impact is if you can see skid marks that travel in one direction and then suddenly shift in the opposite direction and drag that way.

11. **What is the difference between the dead load and the live load of a building**? Dead loads are loads that never seem to change in a building, such as the weight of the floors, walls, supports and roof. Live loads are loads that can sometimes change due to weather, occupancy, or building use. They include such things as the temporary weight of snow or ice on the roof, the weight of the people in the building and where they are congregated at various times of the day, and the weight of furniture, machinery, and equipment in the building and how they are distributed.

12. **What are dynamic loads in a building**? They are loads on a building that change during a relatively short period of time. They are repeatedly applied and released. Dynamic loads add to the static loads that a building must be able to handle, which means that a building, or perhaps certain parts of a building, must be made even stronger than is required to handle its static loads. Unexpected dynamic loads eat into a building's margin of safety. They typically include forces due to strong winds, gusting, or winds from varying directions; machinery inside the building or nearby that pounds or shakes the floor and walls. And ground motion such as earthquakes, heavy traffic, or nearby construction work. Dynamic

loads, when sufficiently strong and when applied often enough, can cause some materials to fail due to material fatigue.

13. **What caused the Tacoma Narrows Bridge to collapse**? Excessive dynamic loading. It tended to sway and wave excessively on windy days. The waves in Gertie were caused by aerodynamically induced dynamic forces applied to the bridge decking that were not anticipated by the designer. Crosswinds under and over the bridge decking caused the decking to alternately lift like an airplane wing and then drop. The alternate lifting and falling eventually tore the decking apart and the decking failed catastrophically.

14. **When the WTC was designed, what kind of possible aircraft accident was envisioned**? Boeing 707 jet aircraft. At the time the Boeing 707 was the largest commercial aircraft in use. It has a maximum takeoff weight of about 336,000 pounds, a wingspan of 146 feet, a length of 153 feet, a tail height of 52 feet, and a cruising speed of 607 mph. When fully fueled it contains about 23,000 gallons of fuel. It was presumed that if an impact were to occur, the velocity at impact would be similar to landing or takeoff velocity, perhaps 180 mph.

15. If a Boeing 707 instead of a Boeing 767 had struck a WTC tower under the conditions assumed for an accidental impact during take-off, how would its kinetic energy compare to that of the aircraft that struck it on September 11, 2001?

16. **Did the impacts of the aircraft into the two towers of the WTC directly cause the towers to collapse? Why or why not**? No. Both towers withstood the impact well. It was the unexpected fuel that caused the buildings to come down. The fire burned at such a high temperature that the metal support beams used in the center of the building, began to melt and weaken. When one section failed, the weight of that section crushed down upon the lower floor. That weakened an already floor and when the heat from the fire continued to burn down on that level the steel melted and again the floor dropped. This repeated until the domino effect took place and the entire building came down. If the fire had not burned as hot as it did and for as long as it did, the floors would have held.

17. **What happens to steel when it is heated in an intense fire**? Structural steel loses approximately half of its tensile strength at 1000 degrees Fahrenheit. At 1300 degrees Fahrenheit and higher, it loses most of its strength and stiffness and ceases to be a viable structural component.

18. **How do demolition experts use small explosive charges to collapse large buildings deliberately?** Small explosive charges are used to take out well chosen structural members so that the resulting falling mass from an upper portion of the building drops onto and crushes a lower portion of the building, which in turn falls upon even lower portions of the building. It is a sort of controlled avalanche. In a sense, the inherent potential energy of the building due to gravity is harnessed to destroy itself.

Chapter 19: Forensic Computing

- Difficult evidence because evidentiary may be hidden through steganography and encryption.
- Difficult to detect and quite fragile.
- Dealing with global nature evidence, multijurisdictional issues, appropriate judicial search warrants.
- Files can be moved from one computer to another throughout the world in a matter of milliseconds. Can be hidden in slack space in a computer hard drive or stored on a remote server in other geographic jurisdictions. Files can be encrypted, misleadingly titled, or commingled with thousands of unrelated, innocuous, or statutorily protected files.
- Can be unrecognized, be lost, if not properly processed. Me must ensure integrity of digital evidence, because it is easily alterable.
- Computer communications can occur by using a RAM cache, thus avoiding writing to the hard drive, and this can occur in a networked environment from any point to any other point.
- Investigators can look for a suspect in four locations digitally:
    - Computer hard drive
    - File servers
    - Databases from governmental agencies as well as private/corporate
    - Electronic record systems from governmental to private and commercial sector
- **Bitstream Data Copy**: Duplicates all data in a cluster, including anything that is in the extra space where digital forensic evidence may be hidden; bitstream data copy should be copied to a working copy of the disc so analysis will not contaminate evidence.
- **Pixel Defects**: A strong kind of evidence in a camera. Areas in a picture where the defect repeats itself and can be traced back or identified to one camera.

Chapter 19 Review Questions:

1. **What are the major challenges investigators confront with digital and electronic evidence in the new electronic crime scenes**? This new environment is unique not only because the evidence may be difficult to detect but also because of how its evidentiary value may be hidden through steganography and encryption. There is a degree of anonymity in which perpetrators can hide their true identity in the forging of certain criminal acts and endeavors. This evidence is both difficult to detect and quite fragile. It might be on a global nature. Crossing many jurisdictional lines. Data can be transferred in seconds from one computer to another.

2. **It is generally accepted as good police practice that, when entering an electronic crime scene, the investigator should follow certain guidelines; identify and discuss these guidelines.**

a. Protect the evidence and, if people are at the scene, do not permit anyone to touch any computers or other electronic instruments. All connectivity, including wireless and Bluetooth, should be disabled if possible.
b. Note if a computer is on or off. If it is on, the screen should be photographed as found. All wires and cords connecting various devices should be labeled to allow for reconstructing the exact configuration once the devices are removed from the computer. Don't unplug from network server.
c. Don't use aluminum based powders on computer equipment, they could create electrical interference.
d. Transport computers with caution so you don't damage or lose the fragile electronic data. Don't put in the trunk of police car where the radio might cause issues/damage.
e. Store and maintain computers and electronic equipment in an environment that is conducive to preserving the data contained in that equipment and is free from any nearby magnetic fields.

3. **Computer crime cases involve a level of complexity that requires the investigator to possess knowledge of both legal requirements and procedural requirements for effecting search and seizure of evidentiary material. Identify the most common mistakes made by the investigator**. Multiple legal jurisdictions may be crossed when doing a search of computers because of how data is transferred. Correct search warrant locations need to be gathered. Also, searching a computer data history or memory may come across signs of other crimes. Unless specifically stated in the search warrant these other items would be gathered illegally.

4. **Describe how the forensic computer investigator collects evidence from a hard drive**. The investigator performing the search of a computer hard drive must be sufficiently trained and educated in the use of appropriate software utilities used in scanning hard drives. Creating a disk image on which to perform the search of the targeted hard drive while maintaining the integrity of the original hard drive and ensuring that none of the data residing on the hard drive are modified by the software utilized to search for appropriate information. The imaged hard drive should also be duplicated for eventual defense motions regarding discovery of the data, in the event the defense counsel wishes their forensic computer experts to review or perform independent analysis of the hard drive.

5. **Why should a bitstream copy of the original storage medium and an exact duplicate copy of the original disk be made**? A bitstream data copy of the original disk should be copied to a working copy of the disk so that the analyst of the data will not contaminate the evidence. In the analysis of the digital evidence, you may have to recover data, especially if the users have deleted files or overwritten them.

6. In the analysis of digital evidence, is it possible to recover deleted files? If so, describe the process one would have to consider using.

7. **Identify the typical cases with which investigators will be involved when the computer is used as an instrument in criminal activity**.
    a. Child pornography and solicitation
    b. Stalking and harassment
    c. Fraud
    d. Software piracy
    e. Gambling
    f. Drugs
    g. Unauthorized access into other computer systems
    h. Denial of service attacks
    i. Data modification
    j. Embezzlement
    k. Identify theft
    l. Credit card theft
    m. Theft of trade secrets and intellectual property
    n. Extortion
    o. Terrorism

8. **When the computer is a target of criminal activity, what types of cases is the investigator most likely to encounter**?
    a. Theft
    b. Virus attack
    c. Malicious code
    d. Unauthorized access
    e. Data modification
    f. Intellectual property and trade secrets
    g. Espionage to government computer systems
    h. Child pornography and child exploitation materials
    i. Stalking
    j. Unauthorized access into other computer systems
    k. Fraud
    l. Software piracy
    m. Gambling
    n. Drugs
    o. Terrorism attack plans/ organization recruiting plans
    p. Credit card numbers in fraud cases
    q. Trade secrets
    r. Government classified documents/espionage

9. **Which precautions should be taken for 3D reconstructions**? It can be difficult to accurately determine size because there might be errors in the measurements or there might not be enough reference points in the image. Furthermore, if someone is bent over, it is not known

how much that height differs from the full height, and the influence of shoe heel height and head size must be taken into account.

10. **Discuss the process of photogrammetry**. Requires many parts of the scene to be measured to determine the height and size of suspects.

Chapter 20: Behavioral Science and Forensic Science:

- **Isaac Ray**: Published his *Treaties on the Medical Jurisprudence of Insanity* in Boston 1838. Began the use of this science in America.
- **American Academy of Psychiatry and the Law (AAPL)**: Maintained a high level of educational function for this board to help with continuing education of forensic psychiatrists.
- **American Board of Forensic Psychiatry (ABFP)**: Board certification in forensic psychiatry was spearheaded by this board.
- **People v. Hawthorne (1940):** Courts were asked to decide whether psychologists should be allowed to give testimony. Court held that there was "no magic of an MD degree" and allowed properly trained psychologist to testify about a defendant's mental state.
- **Hidden v. Mutual Life (1957):** The court permitted psychologists to testify.
- **Jenkins v. United States (1962):** Federal court allowed psychologists to testify as expert witnesses in criminal matters.
- **Psychiatrists:** Are medical doctors whose specialty is psychiatry, which focuses on prevention, diagnosis, and treatment of mental illness.
- **Psychologists:** Are not physicians but often have advanced degrees. Family, civil and criminal law they provide testimony.
- Personality is assumed to dictate behavior that is reflected in evidence left at a crime scene. Personality of both the offender and victims should be explored.
- Psychological testing is a quantitative or quasi-quantitative method of evaluating personality, psychopathology, and mental functioning.
- **Projective Tests:** Are based on the notion that, if an individual is shown an ambiguous stimulus and asked to respond to it, his/her responses will reveal aspects of his/her personality. Ink blot tests.
- **Thematic Apperception Test (TAT):** Subject is shown a number of pictures depicting various everyday situations and is asked to create a story based on the picture; in the process it is assumed, he will reveal his wishes, thoughts, conflicts, feelings, and motives. It is often more helpful in uncovering relevant psychodynamics.
- **Personality Inventories**: Are psychological tests that, unlike the projective techniques, are highly standardized and have considerable empirical validation for what they are designed to assess. They evaluate personality, psychopathology, and mental functioning.
- **Malingering (simulation):** Conscious attempt to feign a mental illness; fake mental illness to avoid criminal responsibility.
- **Dissimulation:** A conscious and deliberate attempt to minimize or deny symptoms of a mental disorder; denying mental illness to be released from prison or a hospital.
- **Insanity:** A mental state in which an individual could not or did not know that what he/she was doing was wrong.
- **McNaughten Rule (England 1843):** Cognitive test of insanity.
- **Durham court case**: Stated that a person would be found not guilty by reason of insanity if the person's behavior was a product of mental illness. This was replaced with the Brawner case of 1972.

- **Brawner case (1972):** Adopted the **Model Penal Code of the American Law Institute** which stated *"a person would be found not guilty by reason of insanity if at the time of the commission of the crime the person lacked substantial capacity either to appreciate the criminality of the behavior or to conform his conduct to the requirements of the law."*
- **Omnibus Crime Code for Insanity**: A person would be found not guilty by reason of insanity if at the time of the commission of the crime the defendant could not ***appreciate*** the criminality of his behavior. (**Appreciate versus knowledge; broadens scope**).
- **A crime consists of two parts**: The guilty act (***actus reus***) and the guilty intent (***mens rea***); insanity indicates a lack of *mens rea*. Therefore, it is improper to state "guilty but insane; rather, "guilty but mentally ill" is used.
- **Diminished Capacity**: Different meanings for different jurisdictions with differing punishments. The individual at the time of the commission of the alleged offense has a diminished ability to meet all criteria for the charges; could not form intent; could not act in a knowing/purposeful manner.
- **Profiling:** The identification of certain characteristics of an unknown, unidentified offender based on the way that he committed a violent act and his interactions with the victims. Investigative analysis of an unsolved crime of violence; may cover victimology, crime reconstruction, significant facts of the autopsy, characteristics and traits of the offender, post offense behavior, and investigative suggestions.
- **Organized Offender:** Clear forethought regarding approach; planning and rehearsing the crime in detail; leaves little to chance and few clues.
- **Disorganized Offender**: Well defined by their impulsiveness, thoughtless approach; messy and chaotic crime scenes.
- **Modus Operandi (MO):** Method of operation of a criminal; the principle that a criminal is likely to use the same technique repeatedly and that any analysis and record of that technique used in every serious crime will provide a means of identification in a particular crime.
- **Signature:** A killer's psychological calling card left at each crime scene across a spectrum of several murders; characteristics that distinguish one murder from all others.
- **Overkill:** Administering more trauma than necessary; indicates personalized anger.

Chapter 20 Review Questions:

1. **What is the difference between MO and signature**? MO is simply the way a particular criminal operates. A killer's personal expression is his signature, an imprint he leaves at the scene, an imprint he feels psychologically compelled to leave to satisfy himself sexually. Unlike the characteristics of an offenders MO, the core signature remains constant. However, a signature may evolve over time, as in some cases where a necrophilia killer performs more and more postmortem mutilation from one murder to the next. What is important about a killer's signature, then, is that killers learn to treat victims the way they do in their fantasies, always attempting to satisfy their fantasies as they move from one victim to the next.

2. **What are the similarities and the differences between forensic psychology and forensic psychiatry**?
    a. Forensic psychiatrists are medical doctors whose specialty is psychiatry, which focuses on prevention, diagnosis, and treatment of mental illness. This can include addictive and emotional disorders such as schizophrenia and other psychotic disorders, mood disorders, anxiety disorders, substance-related disorders, sexual and gender identity disorders, and adjustment disorders. Unlike a psychologist, a psychiatrist can order diagnostic laboratory tests and prescribe medications to treat mental illness and alleviate symptoms. They are called by attorneys/judges to assess individuals for metal state in the past (legal insanity or testamentary capacity), in the present (competency to stand trial or other forms of present competency), or in the future (prediction of dangerousness).
    b. Forensic Psychologists are not physicians but often have advanced degrees. They are involved in assessment, treatment, and provision of testimony in a variety of legal cases in areas such as family law (including custody and visitation matters), civil law (personal injury, workers compensation, wills, and contracts), and criminal law (including the various types of competencies, responsibility, and sentencing). Many psychologists are developing subspecialties in forensic psychology, limiting their practice to one or two types of legal issues such as criminal offenses, sexual harassment, or product liability. In the area of treatment, they provide services to offenders in prison, in lieu of incarceration, or following release, as well as to the victims of crimes.

3. **What does it mean when we say the findings at a crime scene were "internally consistent"? Give an example of what would constitute inconsistent findings**. Internally Inconsistent, which means multiple aspects of the crime scene are inconsistent. They will not fit together logically, nor will they be properly supported by forensic evidence. If the crime scene has been staged, a pattern of incompatible features will likely be discovered. The discovery of inconsistent details may include staging of the point of entry, the items that are missing from the crime scene, or the nature of the assault on the victim. So if you have a scene that has not been staged or the family members have not move/changed things around to hide a suicide, then the evidence will be internally consistent with what you are seeing at the scene.

4. **What is meant by a "projective test"**? Are based on the notion that, if an individual is shown an ambiguous stimulus and asked to respond to it, his/her responses will reveal aspects of his/her personality. Inner thoughts, wishes, conflicts, and feelings will be projected onto the ambiguous stimuli, enabling the psychologist to see the subject's inner life. An example would be the inkblot test, or the test where everyday pictures are shown to a subject and they are asked to tell a story about the photographs.

5. What is the distinction between a clinical and a forensic assessment?

6. Discuss complicating factors in forensic assessment, specifically with regard to deception.

7. **Feigning an illness is called** Malingering aka Simulation.

8. **To be found competent to stand trial, what does a person need to be able to do**? Understand the nature of the charges, the consequences of the charges, and the individual's understanding of the courtroom procedure, including the role of the principals in the courtroom.

9. **For a person to be found legally insane, it must be shown that the person had a mental illness that prevented the defendant from doing what**? Did not know the nature and quality of his/her action. The individual could not or did not known what he/she was doing or what he/she was going was wrong.

10. **For a defendant's statement to the police to be valid, the statement must be** voluntary and understand the Miranda warnings.

11. **How frequently is the insanity defense raised in criminal cases**? Not very often.

12. **For what purpose may a forensic psychologist or forensic psychiatrist be called by the court after a verdict has been given**? The individual may not be competent to be sentenced to prison because he/she is psychotic and requires mental hospitalization.

13. **For what purpose, following a death penalty sentence, may a forensic psychologist or forensic psychiatrist become involved**? The individual may not be competent to be executed in the event he/she is given the death sentence. If they waive their rights to appeals they need to be evaluated to make sure that they are making a competent decision.

14. **What are the McNaughten rules**? Most states follow them. They were promulgated in England in 1843. McNaughten rules are primarily a cognitive test of insanity. Most jurisdictions indicate that a person would be found guilty by reason of insanity if, at the time of the commission of the crime, the person was suffering from such mental infirmity or disease that he or she did not know the nature and quality of his/her action. This is purely cognitive in that the individual could not or did not know what her/she was doing or that what he/she was doing was wrong.

15. Discuss the concept of case linkage analysis and the roles played by MO, signature analysis, and profiling in linking cases.

16. **What is victimology? How is it used**? One good source of information for investigators trying to understand the crime scene involves detailed knowledge of the crime victim's life and lifestyle. The history of a victim in some ways defines the analysis of the crime. So

important is this phase of investigation that the study of the victim must be thorough and undertaken immediately. People have a variety of personality factors, even quirks, which help define them and can contribute to their being targeted. The victim's characteristics may also offer insight regarding the personality of the attacker. Trying to answer the question: "Was the victim's lifestyle a contributing factor toward victimization?"

17. **What is a "profile"? What are its limitations and uses?** Understanding the motivation, thoughts, and forces that drive violent criminal behavior is clearly challenging for those who do not share those predilections. Offenders often leave trace evidence consisting of footprints etc. Likewise, an offender leaves behind traces of behavior at the crime scene. This behavior can be inferred logically by an experienced investigator and this is the basis of what is called generically profiling. To define profiling, it is the identification of certain characteristics of an unknown, unidentified offender based on the way he committed a violent act and his interactions with the victims. By reading the offender's behavior at the crime scene, certain descriptive traits and characteristics can be attributed to the unknown offender. Some traits are learned from witness descriptions, but the most valuable clues are based on a combination of crime scene examination, investigative experience, an understanding of offender and victim behaviors, knowledge of wound patterns, forensic evidence, and the existing research in the field.

18. **What are trophies and souvenirs? How are they similar and how are they different**? They are items that are closely identified with the victim or the commission of the crime. They are called either a trophy or a souvenir, depending on the meaning placed on them by the offender's mental process. In the mind of the offender, the item retained may represent an accomplishment, a victory within the context of his criminality, so it is retained as a trophy. For other offenders, the same item would represent, to him, a fondly remembered occurrence and is retained as a souvenir for inclusion in his masturbatory fantasies.

19. **Discuss the role of fantasy in criminal conduct. How can fantasies be revealed at the crime scene**? Fantasies are powerful forces in shaping violent criminal acts. Fantasies play a critical role in many crimes but have their greatest impact in sexually violent crimes. Fantasies do not create criminality, but they do reinforce and deepen criminal thought. Fantasies are daydreams. They may be positive and enriching, or they may be negatively focused on power, control, and domination. Fantasies may be visualized on a continuum, ranging from the low point of repetitive, underdeveloped thoughts through repetitive, detailed, well developed, elaborate, and coherent thoughts. Offenders using the latter type of fantasy are noted for having more "evidence-free" crimes due to the repetitive nature of the thinking pattern wherein the criminal planning is more extensive, more well-rehearsed mentally, and subsequently more effective. Criminal sophistication can often be seen in this type of criminal fantasy. A prime reason for the difference in fantasies and, hence, a difference in offenders is the ability to use imagination. Imagination is a forerunner and indicator of intelligence. Intelligence in fantasy generally leads to more effective planning and corrective thinking that is often seen as criminal sophistication. Hence, the more

elaborate the fantasy, the more evidence the sophistication and the more difficult the task of the investigator.

20. **What is the meaning of the terms *actus reus* and *mens rea*? How do these concepts relate to behavior forensic science**? A crime consists of two parts: the guilty act (actus reus) and the guilty intent (mens rea). To vitiate one of those (that is, the mens rea by insanity) could not then lead to a guilty finding. The concept of "guilty but mentally ill" was adopted by 13 states. American Law Institute Model Penal Code, which is that a person lacked substantial capacity because of mental illness either to appreciate the criminality of his or her behavior or to conform his/her conduct to the requirements of the law.

21. **How could an organized offender be differentiated from a disorganized offender based on physical evidence at the crime scene**? Interviews with experienced criminals and a review of their criminal acts revealed two distinct patterns in homicidal offenders, with some actors falling in the middle ground.
    a. Organized Offenders: exhibit clear evidence of forethought regarding their approach to and subsequent dealing with a victim. They plan and rehearse the crime in detail, allowing for variances in victims and locations. They conceive, before the crime, what will be necessary to prevent identification and apprehension and what tools or implements will be needed to efficiently deal with the victims in the manner they desire. Within the constraints of their ability to fantasize and imagine, they leave little to chance. They leave few clues as to identity and select victims who cannot be linked to them.

Disorganized Offenders: Are well defined by their impulsiveness and generally thoughtless approach to crime. Their crimes will typically be messy and chaotic, with reliance on using criminal tools readily available at the crime scene. Their lack of planning often results in abundant clues to their identity and a plethora of identity linking evidence at the crime scene. Cardinal indicators of disorganization are usually found in the evidence surrounding their ability to approach, obtain, and maintain control of the victim throughout the crime.

Chapter 21: The Future of Forensic Science:

- **Mass casualty event:** An event which requires a forensic response even when there is no *crime per se*
- **Virtual autopsy ("virtopsy"):** Performing autopsies without requiring a single cut. This method takes advantage of advanced medical imaging techniques such as magnetic resonance imaging (MRI) and computer assisted tomography (CAT) scans to create a virtual image of a body from bones to soft tissue while minimizing the need for actual dissection.