

An Introduction to Forensic Science

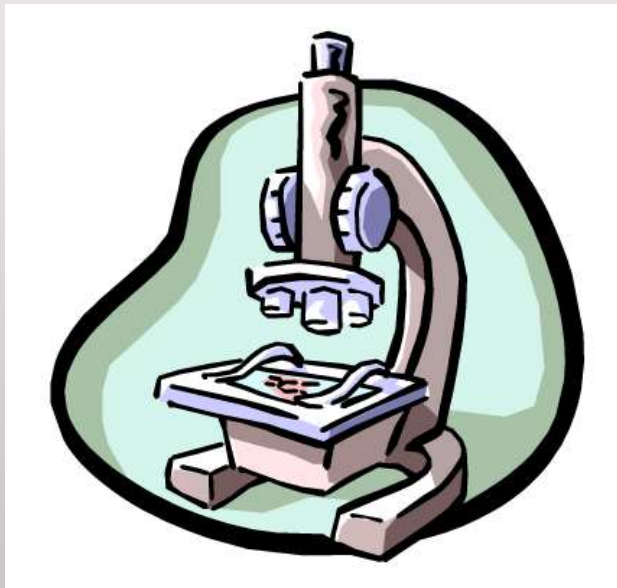
What is Forensic Science?

- ...the application of science to those criminal and civil laws that are enforced by police agencies in a criminal justice system.



Forensic Science is...

- Applied Science
- Often called “criminalistics”



Forensic Science applies

- Chemistry
- Biology
- Physics
- Geology



to civil and criminal law

Places physical evidence into a professional discipline.

CHEMISTRY

Branch of science that deals with the study of the composition of matter and different changes that it undergoes

Forensic Chemistry

- Specialized sub-field of forensic science involving the application of techniques and principles of chemistry to the field of forensic investigation
- Involves complex procedures of chemical analysis that are used to identify elements and compounds
- Identification procedures are highly reliable
- Identification is based on the physical and chemical properties of the substance supported by the data obtained from analytical analysis

Forensic chemists analyze non-biological trace evidence found at crime scenes in order to identify unknown materials and match samples to known substances.

Main task:

- Identification
- Quantification



MAJOR CHALLENGE

Most samples examined are not pure substances, but are often mixed with dirt or debris

WHAT EXACTLY DOES A FORENSIC CHEMIST DO??

- Analyze any non-biological materials found at a crime scene
- Link the suspect to the crime
- Determine the chemical makeup of the material (nature and composition)
- Perform various types of tests, depending on what the material is, to find its origin
- Prevent contamination of the sample during testing
- Document his or her findings in an official report
- Testify about the findings in a court of law.



SCOPE AND SIGNIFICANCE

1. Examination of petroleum products like diesel, petrol, and kerosene



2. Analysis of various narcotic, designer and abused drugs like bhang, opium, ganja, LSD etc. as well as illicit liquors



3. Determination of alcohol in blood and urine



4. Examination of low standard construction material like cement, bricks, etc.



5. Examination of metal alloys and metal fragments



6. Examination of inflammable material in suspected cases of arson, dowry deaths, etc



7. Analysis of explosives, firearms and ammunition



8. Analysis of dyes, paints, inks, fillers, binders and various other chemicals like capsaicin spray, tear gas



9. Drug screening of athletes



10. Trap Cases



11. Analysis of fermented wash, varnish, etc. In prohibition and excise cases



12. Analysis of pesticides and insecticides



TECHNIQUES EMPLOYED BY FORENSIC CHEMISTS

Vast range of analytical techniques are generally employed in forensic analyses

Choice of technique and instrument to be used depends on the type of sample to be analyzed

1. UV- visible Spectrometry

Distinguish between samples of proteins and nucleic acids

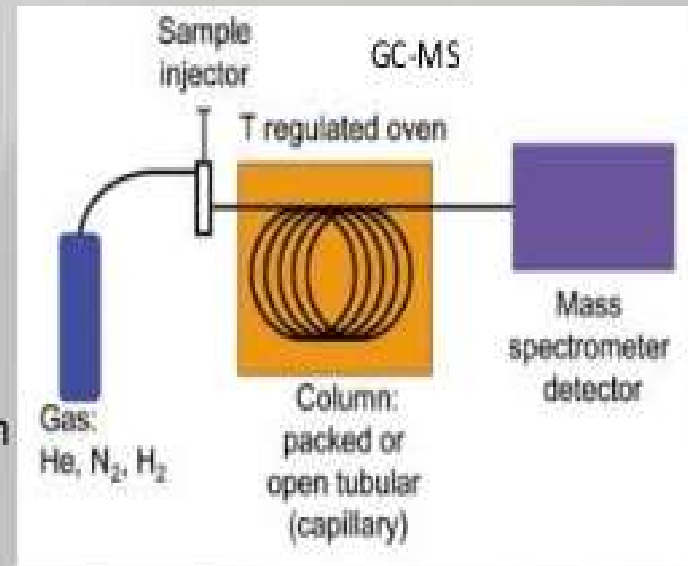


2. Mass Spectrometry

Breaks samples apart and separates the ionized fragments by mass and charge.

3. Gas Chromatography

Separates volatile substances into separate components by passing the volatile materials through a long absorbent column.



GC-MS

- Provide a close match of the unknown accelerant to a known source such as a gasoline tank or hardware store
- Identify and quantitatively analyze the traces of ignitable liquid residue in collected samples
 - Used in investigations of arson, poisoning, and explosions

4. Thin Layer Chromatography (TLC)

- Analysis of different toxins
- Analyze inks and dyes
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5. High Pressure Liquid Chromatography (HPLC)

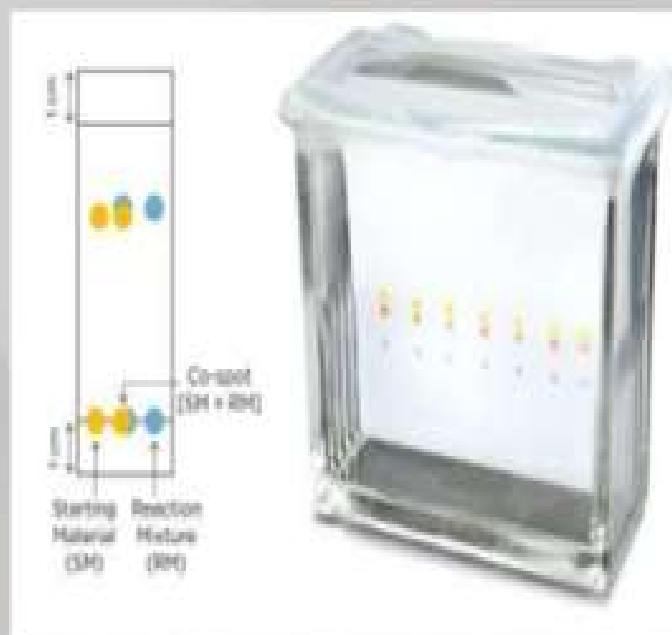
- Separates different types of drugs
- Used for nonvolatile mixtures

6. Infrared Spectrophotometry

- Identification of organic compounds as bonds between certain atoms readily absorb infrared radiation (IR)

7. Atomic Absorption spectrophotometry

- Provides ways of determining absorption and emission spectra, useful tools in the analysis of metals such as bullet fragments.
- Useful in cases of suspected heavy metal poisoning

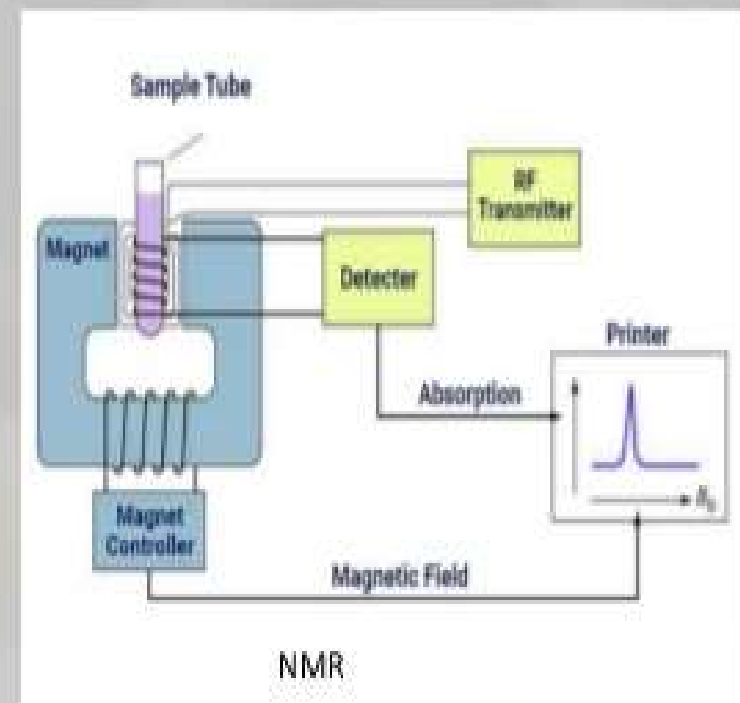


8. Nuclear magnetic resonance spectrophotometry (NMR)

makes use of the fact that nuclei of some molecules absorb radio frequency radiation in strong magnetic fields. Nuclei in certain molecules absorb radiation at characteristic frequencies, making the identification of even tiny or impure samples possible

9. Neutron Activation Analysis (NAA)

- A beam of neutrons from a nuclear reactor is directed at a sample of test material. The material becomes temporarily radioactive, emitting γ -rays that are characteristic of the composition. Analysis of the γ -radiation provides a highly accurate and reproducible determination of the content of the sample.
- Determination of arsenic in the hair of corpses buried for hundreds of years



Organization of a Crime Laboratory

Crime Labs

- Since the 1960's the number of crime labs increased due to the courts demanding secure scientifically evaluated evidence.
 - More crime
 - More drug related crime
 - Greater need for physical evidence
 - Use of DNA profiling (1990's)

Presently there are 350 Crime Laboratories in the U.S.

Services of the Crime Lab

- Many local crime laboratories have been created solely for the purpose of processing evidence
 - Currently most of their energy and funds are used to analyze drugs and DNA.
- In 1932, Hoover first established a national forensics laboratory to support all law enforcement in the U.S.
- The oldest American forensics laboratory is in Los Angeles, California, created in 1923 by August Volmer.

Crime Lab Units

Standard

Physical Science

Biology

Firearms

Documents

Photography

Optional

Toxicology

Fingerprints

Polygraph

Voice Print

Evidence

Basic Services Provided by Full-Service Crime Laboratories

- **Physical Science Unit:**

- Applies the principles and techniques of Chemistry

Physics

Geology

to the identification and comparison of crime-scene evidence

- **Biology Unit:**

- Identifies dried bloodstains and body fluids
- Compares hairs and fibers
- Identifies and compares botanical materials such as wood and plants
- Performs DNA analysis

Basic Services (continued)

- **Firearms Unit:** examines
 - Firearms
 - Discharged bullets
 - Cartridge cases
 - Shotgun shells
 - Ammunition of all types
- **Document Examination Unit:**
 - Analyzes handwriting, paper and printers of documents
- **Photography Unit:**
 - Examines and records physical evidence at the crime scene and at suspects' locations

Optional Services Provided by Full-Service Crime Labs

- **Toxicology Unit:**

- Examines body fluids and organs in order to determine the presence and identification of drugs and poisons

- **Latent Fingerprint Unit:**

- Processes and examines evidence for latent fingerprints
- i.e. those found on surfaces

- **Polygraph Unit:**

- Uses lie detectors, an essential tool of the crime investigator rather than the forensic scientist

Optional Services (continued)

- **Voiceprint Analysis Unit:**

- Involved in cases of telephone threats or tape-recorded messages
- Investigators may be able to connect a voice to a particular suspect

- **Evidence-Collection Unit:**

- Incorporates evidence collection into a total forensic science service

The Functions of the Forensic Scientist

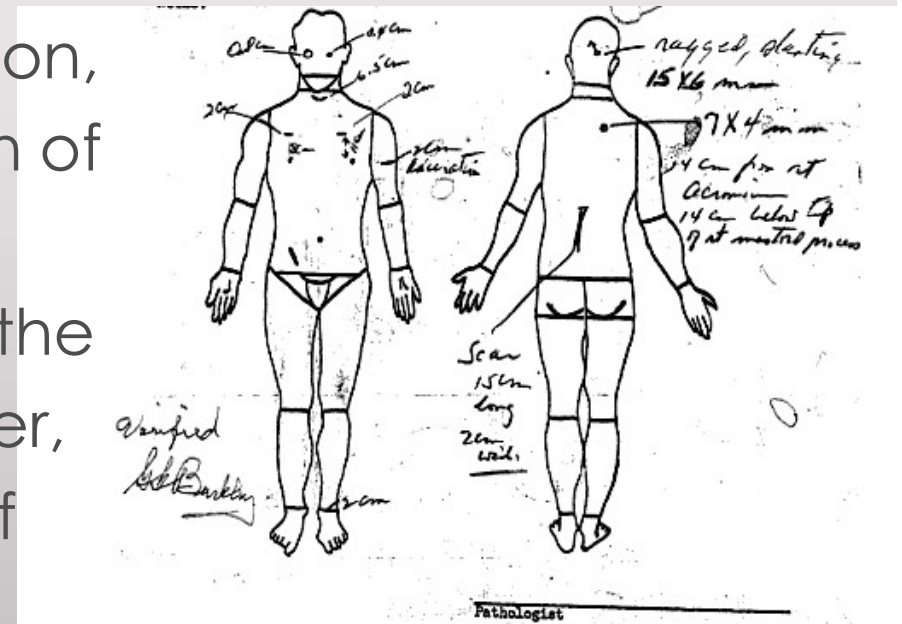
- Analysis of Physical Evidence
 - The forensic scientist must be skilled in applying the principles and techniques of the physical and natural sciences in order to identify the many types of evidence that may be recovered during crime investigations.
- Expert witness
 - An expert witness possesses a particular skill or has knowledge in a trade or profession that will aid the court in determining the truth.

The Functions of the Forensic Scientist

(continued)

- Specially trained evidence collection technicians

- Training in Proper Recognition, Collection, and Preservation of Evidence is required so that the forensic pathologist, as the medical examiner or coroner, can determine the cause of death via an autopsy.



Other Forensic Services

Death can be classified into five different categories: natural death, homicide, suicide, accident or undetermined manner of death.

- **Forensic Pathology**

- The cause of death is determined by performing an

autopsy. The manner of death can be determined



Other Forensic Services - 2

- **Forensic Pathology – continued**
 - After a human body expires there are several stages of death
 - **Rigor Mortis**
 - immediately following death, the muscles relax and then become rigid, shortening of the muscles.
 - **Livor Mortis**
 - when the human heart stops pumping, due to the blood begins to settle in the parts of the body closest to the ground due to gravity. The skin will appear dark blue or purple in these lower areas close to the ground.
 - **Algor Mortis**
 - the process in which the body temperature continually cools after death until it reaches room temperature, enabling the medical examiner to establish the general time of death.

Other Forensic Services - 3

- **Forensic Anthropology:**

- Primarily involves the identification and examination of skeletal remains, in order to determine if the remains are human or another type of animal.
- If human, ethnicity, sex, approximate age, and manner of death can often be determined by an anthropologist.

Other Forensic Services - 4

- **Forensic Entomology**

- The study of insects and their developmental stages
- Can help to determine the time of death by knowing when those species normally appear in the insect's life cycle



Other Forensic Services - 5

- **Forensic Psychiatry**

- The study of human behavior and legal proceedings in both civil and criminal cases
- In civil and criminal cases, competency often needs to be determined
- In criminal trials, the evaluation of behavior disorders is often required in order to establish the psychological profile of a suspect.

Other Forensic Services - 6

- **Forensic Odontology**

- An odontologist can match bite marks to a suspect's teeth, or match a victim to his dental x-rays
- Results in an identification of an unknown individual

- **Forensic Engineering**

- Used to analyze construction accidents, and the causes and origins of fires or explosions

Forensic Analysis

- Can include organic and inorganic analytical techniques
 - **Organic analysis** of unknown substances
 - Includes analytical techniques such as Chromatography, UV- visible and infrared Spectrophotometry and Mass Spectrometry.
 - **Inorganic analysis**
 - Includes techniques such as the emission spectrum of elements, Atomic Absorption Spectrophotometry, Neutron Activation Analysis, and X-Ray Diffraction Analysis.