Forensic Chemistry

Basic Terms

- **Forensic (adj)**
  1. pertaining to, connected with, or used in court of law or public discussion and debate
  2. adapted or suited to argumentation; rhetorical
- **Forensic science (n.)**
  - the application of science to criminal and civil laws.
  - Emphasizes the application of science to criminal and civil laws that are enforced by police agencies in a criminal justice system.
  - Adversarial system
  - owes its origins to individuals such as Bertillon, Galton, Lattes, Goddard, Osborn, and Locard, who developed the principles and techniques needed to identify or compare physical evidence.

Basic Terms

- **criminalistics (n)**
  - the science dealing with the detection of crime and the apprehension of criminals
  - derived from the German “Kriminalistic”
    - coined in early 1900's to attempt to better describe the emerging discipline of “police science”.
- **Forensic CHEMISTRY**
  - Applied analytical chemistry
    - Qualitative, quantitative AND Comparative
    - LOTS OF STATS AND PROOF!
    - Identify, classify and qualify

What makes a Science Forensic?

- An experimental result has no standing until it is disseminated to the rest of the scientific community
  - peer-reviewed journal
  - allows the experiment to be repeated & the results reproduced
- Data is not considered valid until reproduced by an independent source
The Null Hypothesis

- The stated idea is untrue
- Often assumed in forensic science
  – “bullet didn’t come from this gun”
- Failure to disprove the null hypothesis
  – provides evidence that the bullet did pass through the gun

The Scientific Method

1. State an hypothesis (What is the question?)
   - “I think that this bullet came from that gun”
   - We often set out to prove the null hypothesis
   - Formulating a hypothesis is not bias although bias can cause the wrong question to be asked
     * “How did O.J. kill Nicole Brown Simpson & Ron Goldman?” (Wrong)

2. Design an experiment to test the hypothesis
   - Compare the bullet microscopically with other test bullets known to have been fired from the gun
   - Test bullets are the reference samples to which the crime scene bullet will be compared

3. Make observations and record data
   - Photograph the questioned & reference bullets through the microscope
   - Record the number of features in common
     * How many
     * Where they are located
   - A general impression that they were the same or that they were not the same is not acceptable

Standards and Controls

- Experiments include standards & controls
  - Controls
    * Samples for which the results are known
    * Show that the experimental system is working properly
      - Microscope must be calibrated so the two bullets fired from the same gun can be matched up
  - Standards
    * Devices with which the results of an experiment can be measured

- Normally in research, only one variable at a time is changed
  - Allows the establishment of cause & effect
    * When temp is varied (the variable), water assumes different forms (the outcome)
- In forensic science, the original conditions that produced the sample are unknown
  - Many conditions may have acted to produce the sample as it was found
Standards and Controls

- Forensic analysis is an uncontrolled experiment
- You can establish that lab tests have worked properly
- Some aspects of the sample will remain unknown

The Scientific Method

4. Analyze and interpret the data
   - once data is collected, it must be analyzed
   - bullet comparison
     - analysis
       - scrutinize the marks to determine if any differences between the questioned and known bullet are not relevant to the comparison
     - interpretation
       - how many marks need to be similar between the evidence bullet and a test bullet to convince the examiner that the bullet couldn't have come from another gun

The Scientific Method

5. Draw a conclusion
   - At the end of the experiment
   - data must be summarized
   - a statement of the meaning or the data in the context of the hypothesis must be made
     - the number of similar marks are sufficient to declare that both bullets came from the same gun
     - null hypothesis disproved within the limits of the test system

The Scientific Method

6. Define the next question
   - often the answers obtained generate more questions
   - the next set of experiments is planned
   - in forensic science both time and sample are limited
   - often conclusions must be drawn from only one experiment or limited data
   - understanding limitations for any particular system is important

Forensic History

- Mathieu Orfila—the father of forensic toxicology.
- Alphonse Bertillion—devised the first scientific system of personal identification in 1879.
- Francis Galton—conducted the first definitive study of fingerprints and their classification.
- Leone Lattes—developed a procedure to determine blood type from dried bloodstains.
- Calvin Goddard—used a comparison microscope to determine if a particular gun fired a bullet.
- Albert Osborn—developed the fundamental principles of document examination.
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1920’s: A method used to calculate thickness of muscle on skull was developed

1930: National fingerprint file set up by FBI

1930’s: Scanning electron microscope designed by Zworykin

1932: FBI forensic laboratory established

1940’s: Dental records and teeth from corpse were compared

1957: Skeletal growth stages developed by Mocker and Stewart

1960: First laser design to identify fingerprints was developed

1967: FBI NCIC Established

1971: Photo-fit enables witness to piece together facial features

1978: ESDA developed by Freeman and Foster

1980: Method for detecting DNA differences developed

1983: First use of PC’s in patrol cars to provide quick information from NCIC

1984: Genetic profiling using DNA was developed by Jeffries

1987: First time DNA evidence was used to convict a person in the US

The Crime Lab

- The development of crime laboratories in the United States characterized by rapid growth accompanied by a lack of national and regional planning and coordination.
- At present, approximately 350 public crime laboratories operate at various levels of government—federal, state, county, and municipal.

The Crime Lab

- The increasing number of crime laboratories is partly the result of the following:
  - Supreme Court decisions in the 1960s responsible for police placing greater emphasis on scientifically evaluated evidence.
  - Crime laboratories inundated with drug specimens due to rampant drug abuse.
  - The advent of DNA profiling.

Technical Support

- The support provided by crime laboratories can be assigned to five basic services.
  - Physical Science Unit incorporates chemistry, physics, and geology to identify and compare physical evidence.
  - Biology Unit applies the knowledge of biological sciences in order to investigate blood samples, body fluids, hair, and fiber samples.
  - Firearms Unit investigates discharged bullets, cartridge cases, shotgun shells, and ammunition.
Technical Support
– Document Unit provides for handwriting analysis and other questioned-document issues.
– Photographic Unit applies specialized photographic techniques for recording and examining physical evidence.
– Some crime laboratories may offer optional voiceprint analysis, evidence collection, and polygraph administration.

Technical Support
• Optional Services by Full-Service Labs
  – Toxicology Unit examines body fluids and organs for the presence of drugs and poisons.
  – Latent Fingerprint Unit processes and examines evidence for latent fingerprints.
  – Polygraph Unit conducts polygraph or lie detector tests.
  – Voiceprint Analysis Unit attempts to tie a recorded voice to a particular suspect.
  – Evidence-Collection Unit dispatches specially trained personnel to the crime scene to collect and preserve physical evidence.

Special Forensic Science Services
• A number of special forensic science services are available to the law enforcement community to augment the services of the crime laboratory.
• These services include forensic pathology, forensic anthropology, forensic entomology, forensic psychiatry, forensic odontology, computer science, and forensic engineering.

Special Forensic Science Services
• Forensic Pathology involves the investigation of unnatural, unexplained, or violent deaths.
  – Forensic pathologists in their role as medical examiners or coroners are charged with determining cause of death.
  – The forensic pathologist may conduct an autopsy which is the medical dissection and examination of a body in order to determine the cause of death.

Special Forensic Science Services
• After a human body expires there are several stages of death.
  – Rigor mortis results in the shortening of muscle tissue and the stiffening of body parts in the position at death (occurs within the first 24 hours and disappears within 36 hours).
  – Livor mortis results in the settling of blood in areas of the body closest to the ground (begins immediately on death and continues up to 12 hours).
  – Algor mortis results in the loss of heat by a body (a general rule, beginning about an hour after death, the body loses heat by 1 to 1-1/2 degrees Fahrenheit per hour until the body reaches the environmental temperature).

Special Forensic Science Services
• Forensic Anthropology is concerned primarily with the identification and examination of human skeletal remains.
• Forensic Entomology is the study of insects and their relation to a criminal investigation, commonly used to estimate the time of death.
• Forensic Psychiatry is an area in which the relationship between human behavior and legal proceedings is examined.
Special Forensic Science Services

- Forensic Odontology involves using teeth to provide information about the identification of victims when a body is left in an unrecognizable state; also investigates bite marks.
- Forensic Engineering is concerned with failure analysis, accident reconstruction, and causes and origins of fires or explosions.
- Forensic Computer Science involves the examination of digital evidence.

Skills of a Forensic Chemist

- A forensic chemist must be skilled in applying the principles and techniques of analytical chemistry to the specific analysis of the many types of evidence recovered during a criminal investigation.
- A forensic chemist may also provide expert court testimony.
- An expert witness is an individual whom the court determines possesses knowledge relevant to the trial that is not expected of the average person.

Skills of a Forensic Chemist

- The expert witness is called to evaluate evidence based on specialized training and experience that the court lacks the expertise to do.
- The expert expresses a scientifically relevant opinion as to the significance of the findings.
- Forensic chemists participate in training law enforcement personnel in the proper recognition, collection, and preservation of physical evidence.

The Law and the Analyst

- The criminalist has no function without the judicial system
- The analyst’s job
  – provide scientific info to the legal community
  – translate the story the evidence has to tell
- Analysis is done only at the behest of someone seeking to introduce the evidence into a court of law (prosecution or defense)

Circumstantial Evidence

- All physical evidence is circumstantial
  – its involvement has not been substantiated by an eyewitness
  – often the term circumstantial evidence carries the connotation of untrustworthiness
  – eyewitness evidence tends to be considered conclusive

Circumstantial vs. Eyewitness

Scenario:
You are camping in a cabin deep in the woods in the mountains during the winter. Several feet of snow cover the ground. You hear a sound in the middle of the night and go to the window to see what it is. The moon is new so it is almost pitch dark.
Circumstantial vs. Eyewitness

You see a quickly moving shadow that almost blends into the snow.

• Is it a polar bear?
• Is it a burglar dressed in white?

The next morning find

• clear snowshoe tracks
• the lock on your tool shed is hanging open
• some of your tools are missing

Circumstantial vs. Eyewitness

Which is more convincing?

• midnight glimpse
  – eyewitness evidence
• prints in the snow
  – circumstantial evidence

Circumstantial vs. Eyewitness

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The Frye Standard

• The Frye v. United States decision set guidelines for determining the admissibility of scientific evidence into the courtroom.
• To meet the Frye standard, the evidence in question must be “generally accepted” by the scientific community.

The Daubert Criteria

• In Daubert, the Supreme Court offered some guidelines as to how a judge can gauge scientific evidence:
  1) Whether the scientific technique or theory can be (and has been) tested.
  2) Whether the technique or theory has been subject to peer review and publication.
  3) The technique’s potential rate of error.

Frye Not Absolute

• In the 1993 case of Daubert v. Merrell Dow Pharmaceutical, Inc., the U.S. Supreme Court asserted that the Frye standard is not an absolute prerequisite to the admissibility of scientific evidence.
• Trial judges are ultimately responsible for the admissibility and validity of scientific evidence presented in their courts, as well as all expert testimony.
The *Daubert* Criteria

4) **Existence and maintenance of standards** controlling the technique.
5) Whether the scientific theory or method has attracted **widespread acceptance** within a relevant scientific community.