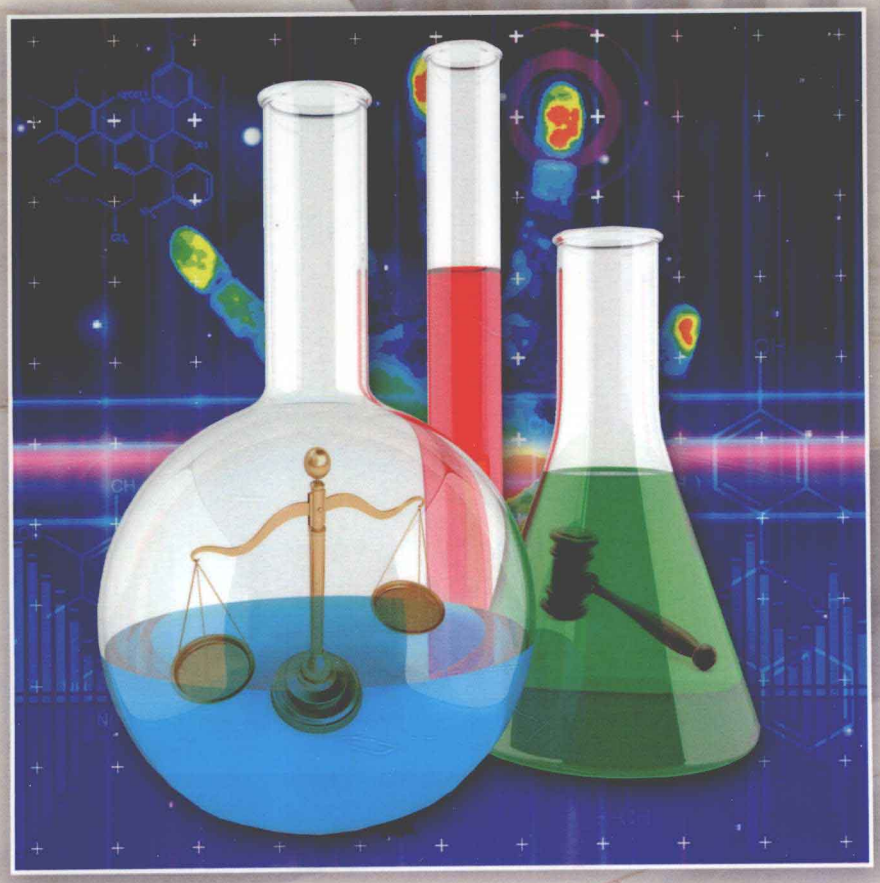
Forensic Science Advances and Their Application in the Judiciary System



Edited by

Danielle Sapse and Lawrence Kobilinsky

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I would like to thank my family, Estelle, Hayley, and Ben, for allowing me to pursue this book and to especially thank Danielle Sapse, who worked diligently to make this significant project a success. It has been a great pleasure for me to work with her.

Lawrence Kobilinsky, PhD

I dedicate this book to my beloved father, Marcel Sapse, who passed away in 2004.

Danielle Sapse, JD

Foreword

Forensic science is an umbrella discipline incorporating many fields such as document examination, toxicology, pharmacology, serology, ballistics and explosives analysis, arson investigation, trace evidence (e.g., hair/fibers, glass, soil, paint), pathology, anthropology, and odontology. Chemistry is a component of each of these disciplines. The tools of the practitioner range from the common light microscope to the most sophisticated analytical instruments. Regardless of the specific instruments that criminalists use to solve crimes, the one clear need is that the scientific method be used to try to exclude or associate a suspect with a crime scene or victim. This will insure the reliability and admissibility of scientific evidence in the courtroom. The analysis of physical evidence identified at a crime scene can be critical to solving any crime. Observation of items of importance and their documentation, collection, and packaging, followed by experimental analysis in the laboratory, can often either prove or disprove a hypothesis. Test results can contribute to an understanding of what occurred at the crime scene, prior to and during the commission of the incident. Crime scene investigation must be done properly and thoroughly for laboratory personnel to acquire the most accurate information about the evidence and crime scene.

Over the past decade many achievements have been made in forensic science and there have been exciting advancements in the technology available to crime scene personnel and laboratory analysts. Many of the newer methods employed by criminalists are based on sound scientific research and have extraordinary sensitivity and specificity. Wherever possible, analysis of evidence should provide quantitative data, which can subsequently be analyzed statistically. The analysts' unbiased conclusions are then made based on sound scientific principles utilizing the scientific method.

This book describes such methods and provides insight into their impact on forensic science and criminal justice. For example, nuclear magnetic resonance (NMR) and quantum chemistry are now applied to certain problems related to forensic science such as the analysis of licit and illicit drugs. For the results of analyses to be useful to jurors in criminal cases, this scientific evidence must be deemed reliable and admissible by judges who serve as gatekeepers of novel scientific evidence. The results must add to the understanding of the jurors and assist them in finding a defendant guilty or not guilty. To explore in depth the role of forensic science in the judiciary process, the first chapter of the book discusses scientific evidence, describing several criminal cases whose outcome has been largely decided based on forensic evidence analysis.

Forensic science has played a very important role in the litigation of cases involving illicit drugs. Chapters 2 and 4 present the legal and chemical aspects in the detection and analysis of a major class of abused drugs, the methamphetamines. Some of the methods used to clarify the circumstances in which a crime has been committed are related to DNA. Chapter 3 describes new methods used for the analysis of DNA obtained from botanical evidence as well as from insects. Such evidence can sometimes be used to determine the identity of the victim or suspect after a crime has been committed.

The next few chapters discuss new applications of chemical methods to forensic science. Among those, quantum chemistry calculations as applied to systems of forensic interest, such as toxins, fingerprinting agents, and the synthesis of methamphetamines, are comprehensively discussed in Chapter 4.

Chapter 5 describes various legal aspects of the utilization of DNA in the analysis of biological evidence. Different cases are presented in which DNA analysis is used either for convicting a criminal or for exonerating an innocent person who has been wrongly accused. This chapter also contains quantum chemistry calculations on the complexes formed by DNA fragments and methyllithium and their potential future use in forensic investigations.

A description of NMR methods and their application to physical evidence analysis in forensic science is contained in Chapter 6.

Some of the most useful procedures for solving homicide cases are the postmortem investigations. Chapters 7, 8, 9, and 10 address this issue, from different points of view. Chapter 7 discusses pharmacogenetics and its role in forensic science. Chapter 8 describes "virtual autopsy" methods, consisting of scientific noninvasive research applied to the bodies of murder victims, with special emphasis on cross-sectional imaging. Another look at the studies of human remains is provided in Chapter 9, which includes DNA studies of ancient remains such as Egyptian mummies.

Chapter 10 discusses postmortem chemical changes that take place upon death of an individual. Forensic and legal issues related to animal cruelty are presented in Chapter 11. Indeed, abuse of animals appears to be strongly correlated with the abuse of women and children. Some of these issues are addressed in this chapter.

One of the purposes of this book is to help solve some of the problems related to forensic investigations. It is hoped that the issues raised and the methods described will contribute to strengthening forensic science in several of these areas.

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DANIELLE SAPSE

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Introduction

At a trial, the culpability or innocence of the defendant is established in different ways. Some of these ways involve the use of forensic science.

Forensic science, the science in the service of the law, comprises many different specialty areas. The area that comprises all the aspects having to do with full-service forensic science laboratories is called criminalistics. Criminalistics involves the identification and interpretation of physical evidence found at the scene of a crime. This evidence can be separated into biological evidence analysis, material evidence analysis, fire debris and substance identification, and pattern evidence such as fingerprints, footwear, and others, and presented to the court during the trial.

Evidence is studied through recognition, identification, individualization, and reconstruction. Recognition takes place at the start of an investigation, and then the physical evidence has to be identified and classified. Chemical evidence is classified in the forensic laboratory by the use of chemical or instrumental techniques. To be of use to the prosecution, and to be accepted by the court, these classifications have to be performed.

Experiments are particularly important when they result in exclusion or disassociation. Indeed, a negative result can be an absolute, while a positive result has to be viewed in terms of probability. For instance, if a fragment of glass is found at the scene of the crime, it may be suspected of belonging to a certain car's headlights. When tests show it to be different, it is clear that it does not belong to the car. If it is similar to the car's headlights, there is always the probability that another car features the same headlights.

Individualization can be the recognition of an object as unique among a certain class, or an unknown item can be identified as having a common origin with a known object. Reconstruction uses the analysis of physical evidence to shed light on the events that took place. Reconstruction might have a speculative aspect, which can lead to an incorrect interpretation. As such, it is used cautiously.

All the relevant findings at a crime scene can be introduced at trials either by the prosecution or the defense and constitute evidence. The use of scientific evidence in court is subject to certain laws.

Evidence law is based on principles and regulations for admitting proof in court. These laws can vary depending on the state. In federal court, rules of evidence are found in a code called the Federal Rules of Evidence, which was developed in 1975 and is used for both criminal and civil cases. There are also individual state codes, which apply to state court cases. This includes both testimony and physical evidence. In criminal cases, the state has the burden of proof to assert that a defendant committed a crime. There must be proof beyond a reasonable doubt that the crime was committed and that the defendant committed it, and this information can be proven by using evidence.

Evidence can be categorized in several different ways. Testimony is spoken evidence, given by witnesses under oath in court. Real evidence is "evidence furnished by things themselves, on view or inspection, as distinguished from a description of them by the mouth of a witness" (Black's Law Dictionary 1990). Some examples are the physical appearance of a person or place, inanimate objects, weapons, and tools. A subcategory of real evidence is scientific evidence, as used in forensic investigations, which will be discussed later.

Another way to classify evidence is whether it is direct or circumstantial. Direct evidence is evidence that proves a fact directly, without having to make any assumptions. For example, if a witness actually saw a crime happen, rather than if he heard about it from another person, that would be direct evidence. Circumstantial evidence is evidence that is not based on personal firsthand knowledge, but rather on other collateral facts. Circumstantial evidence can be admissible, especially when it is combined into a collection of different types of evidence.

One type of evidence that is not usually admissible is hearsay, which is secondhand testimony. That is, the witness does not have personal knowledge of a crime, but he or she heard about it from another person. The reason why hearsay evidence is not usually admitted into court is because the opposing party cannot cross-examine the person who first made the statement. Without cross-examining a witness, it can be difficult to find out if he or she is telling the truth and is accurate. There are, however, certain exceptions as will be shown later.

For evidence to be admissible in court, it must be relevant and trustworthy. Relevant evidence is evidence that can prove, for instance in a criminal case, whether the defendant committed a crime. For example, in many situations, prior convictions might not be relevant, because they would not prove whether the defendant committed the crime for which he is on trial. Information such as this may also wrongfully influence the jury.

Evidence also has to be trustworthy, that is, competent. It cannot violate the exclusionary rule. The exclusionary rule is the rule that states that if evidence is wrongfully obtained, if it is obtained in a way that violates the rights given in the U.S. Constitution, it cannot be admissible and must be excluded from the trial. For example, the Fourth Amendment prohibits illegal searches and seizures. If a police officer conducts an illegal search, such as one

that is performed without a warrant or consent, when necessary, the items found cannot be admissible as evidence. A landmark case on this subject is *Mapp v. Ohio* (1961). In that case, police officers conducted an illegal, warrantless search of Ms. Dollree Mapp's house, while searching for a person suspected of a crime. While searching, they did not find the suspect they were looking for, but they did find some obscene drawings, and Ms. Mapp was charged and convicted for their possession. On appeal, the U.S. Supreme Court overturned the conviction, because of the illegal search.

Evidence, as mentioned before, can be physical evidence or testimony. Testimony, evidence spoken by witnesses, can be of different kinds. There is testimony any time a witness saw a crime happen. In some cases, there are also expert witnesses.

An expert witness is a witness in court who knows more about a certain subject than other people would. An expert witness can talk about both the facts and his or her own opinion, and also help the jury understand technical evidence. There are several rules about the use of expert witnesses in court.

According to the Federal Rules of Evidence, Rule 702, "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...may testify thereto in the form of an opinion or otherwise."

The judge has to decide if it is appropriate for someone to be an expert witness. First, if the evidence is something easy to understand, an expert is not necessary, such as in a case in which an expert had to say that the reason no fingerprints were found on a car was because the person used gloves or wiped away the prints. Expert witnesses are used for information related to science and medicine, but also for any issue where people cannot be expected to understand everything, such as mechanics and vehicles.

There are several ways in which the expert witness might know about the facts of a situation. For example, if the expert is a doctor, he might know the patient's condition because he examined him, because he got his files from another doctor, or by what he hears in court. Sometimes the lawyers will explain a situation to an expert and ask him to give his opinion about it in court. The expert might be questioned in a hypothetical way. For example, a doctor could be asked, "What if someone worked with benzene, and then they get a high fever?" "What is your opinion?"

There is one situation in which an expert is not allowed to give an opinion: "Whether or not the defendant had or did not have the mental state or condition constituting an element of the crime charged or the defense thereto." This is from Federal Rules of Evidence 704(b), and it usually applies to psychiatrists. The reasoning is that the expert can talk about any mental disease that the defendant might have, but only the judge or jury can decide if the mental disease can be a defense to the crime committed.

There is a process that takes place in the court when an expert witness participates in the trial. First, the expert is asked questions by the party who called him or her to court. After the direct examination, the expert goes through a cross-examination, which is conducted by the other side. During the cross-examination, the expert's memory, knowledge, and opinion might be challenged. If the witness makes any statements that are not consistent, it is harmful to his credibility. Also, the examiner might try to find information that would contradict what the expert says (for example, if the expert is a doctor, and the examiner finds contradictory information from a medical book).

As previously stated, *hearsay* is a legal term referring to the use of out-of-court statements as evidence. It is evidence that is not based on the witness's own personal experiences,

but on matters that he was told by another person. Normally, hearsay evidence is inadmissible in court, but there are several exceptions.

Some exceptions are when the declarant gives a statement of his state of mind at the time he gave the declaration, or an "excited utterance," which is a statement made under stress during or immediately after an unexpected event. Also, business records and public records can serve as evidence that an event occurred, since these records are usually kept carefully and accurately, in a routine way.

Another exception, in homicide cases, is the "dying declaration." If the declarant gives a statement while believing that he is about to die, about the reason for why he would die, the statement may be admissible.

A hearsay exception important for scientific evidence is that for "learned treatises." This exception is for written material like textbooks, journals, and periodicals. These can be on a number of different subjects, such as science, history, medicine, and engineering. This type of material can be discussed as part of the questioning of the expert witness, since even though they were written "out of court" they can be assumed to be reliable since they were written by professionals and also evaluated and used by other professionals. For this kind of evidence to work well, the court has to know that the writing is reliable (usually by using an expert) and it must be brought up and discussed during the trial.

Another type of hearsay evidence that is admissible is a declaration of one's physical condition. These are statements that are made to anyone, not just a doctor, that relate to symptoms that the person is feeling at that moment. Statements about past symptoms, the reason for the symptoms, and medical history, are only admissible if they were made to a doctor or other medical professional while in the process of diagnosing and treating the condition.

Description of Scientific Evidence

Physical scientific evidence involves such procedures as fingerprint identification, DNA typing, glass fragment identification through refractive index measurements, and others. Fingerprint analysis and DNA typing are discussed in greater detail in separate chapters.

When scientific evidence is presented at a trial, jurors have to be told about information pertaining to testing errors and also information about the error rate of the laboratory where the tests were done. This is especially important for DNA evidence, which may identify a person. For example, a DNA test might show that the probability of two people's DNA matching is one in a million. However, the probability that the laboratory made a mistake in the testing is one in 500. The jury should be informed of this possibility of error. Most of the time, courts will accept testimony about the statistics of a DNA match.

Most courts allow testimony regarding the statistical possibility of a coincidental match and leave the question of accuracy of the figure to cross-examination. There are controversies related to the fact that population databases are too broad. For instance, if a defendant is part of a specific group featuring a certain genetic pattern in one in 10,000 people, but he is also part of a smaller group which features the pattern in one in 1,000 people, considering the probability as 1 in 10,000 is unfair to the defendant.

Indeed, if a defendant is a member of an insular group, the probability might work in his favor. However, if that group is not the suspect population, the statistical testimony has to be accepted.

For instance, in the case *People v. Mohit*, Dr. Morteza Mohit, a physician in Westchester County in New York State, was accused of raping one of his patients. The defendant was from a town in Iran, Shushtar, where there were people of Persian descent and there was much inbreeding. Being Shiite Muslim, Dr. Mohit claimed that for religious and traditional reasons, inbreeding is very common. However, this is not relevant in a crime committed in New York State. If the crime would have been committed in a region inhabited by Shushtar Shiite Muslims, the probability that the semen belonged to Dr. Mohit would have been much smaller.

Another type of evidence that can be used for identification is voiceprints. Courts do not all agree on whether voiceprints should be admissible. Courts are more likely to accept voiceprints as evidence if the proper methods were used and if the expert is certified by the organization of voice examiners. The cross-examiners can try to show a problem with the evidence. In one case, for example, the government wanted to use voiceprint evidence against a defendant. The defense tried to prove that the background voices in the sample could have caused a mistake.

Expert witnesses can be psychologists and sociologists. They are sometimes called on to testify as experts to explain a person's behavior. For example, some people involved in criminal activity may have Battered Woman's Syndrome or Child Abuse Syndrome, which can show a pattern of typical behavior by abused women or children. This type of evidence is not always admitted.

Another technique used in forensic research is neutron activation analysis (NAA). Neutron activation analysis is a technique for the analysis, identification, and comparison of physical evidence. This elaborate process can isolate and measure very small traces of all kinds of materials such as gunpowder, narcotics, hair, alcohol, and other substances.

The identification and quantitative analysis of the material are accomplished by measuring the gamma rays emitted after the sample has been irradiated by bombardment with neutrons in a nuclear reactor. This method is expensive and requires complicated nuclear equipment, but it is exceedingly accurate in identifying substances and has the advantage that the material analyzed is not damaged and can be preserved for courtroom exhibition.

A party intending to use NAA results as evidence has to offer one or more experts who will testify as to the validity of the process. It is advisable and mandatory even, in a criminal case, to give the other party pretrial notice of the intended use of NAA test results.

In some trials, the degree of intoxication of the suspect plays an important role. Chemical means are used to determine the subject's level of intoxication, for such crimes as drunk driving or crimes supposedly committed under the influence of alcohol. Measurements of the breath, blood, or urine can be used to indicate the approximate amount of alcohol that has reached the brain.

For example, a level of 0.05% or less of blood alcohol means that the subject was probably not under the influence of alcohol. A finding of 0.1% or more shows that the accused is probably intoxicated.

In addition, detection of narcotics use may also be necessary. The drug Nalline can be used to detect the recent use of narcotics (see Figure 1.1). When the drug is injected in a subject, the eye pupils of a recent user dilate.

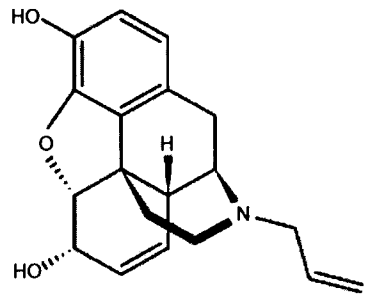

Figure 1.1 Nalline.

The courts have been receptive to Nalline tests. Another test is enzyme multiple immune assay testing of the subject's urine.

Two Landmark Cases: *Frye* and *Daubert*

One of the first major cases that dealt with the issue of the admissibility of scientific evidence was *Frye v. United States*, 293 F. 1013 (D.C. Cir. 1923). This was an appeal of a second-degree murder case, in which the defendant was convicted. At the trial, one piece of evidence was testimony, by an expert witness, about the use of a polygraph test.

A polygraph test, which is also known as a lie detector test, is meant to discover if a suspect is lying or telling the truth. The test works by measuring the suspect's blood pressure along with his respiratory rate and perspiration, while he answers questions. Experts believe that blood pressure depends on the change in the person's emotions. When they show emotions such as fear or anger, their blood pressure will increase. If they are purposefully lying, or if they feel guilty, they will fear being discovered, and their blood pressure will increase. Sometimes, the test might seem to indicate a lie, but in fact, the suspect's blood pressure went up because he is nervous. However, in that case, the blood pressure will eventually return to normal, while if the person is actually lying, the blood pressure will continue to increase.

The *Frye* case attempted to decide if polygraph tests could be admitted as evidence in court. Expert opinions are admissible in court whenever there is an issue that is too intricate for most people to understand and form an opinion about.

This case set an admissibility standard for scientific evidence. The standard states that "a scientific theory or piece of evidence that was accepted by only a minority of specialists would not be admissible at all." The only scientific theories that are admissible and can be presented to the jury are those that were generally accepted by the suitable scientific community. To decide if a procedure is "generally accepted" as necessary, the courts look at previous judicial decisions, as well as books and articles on the subject.

The *Frye* test states that it is important to locate the stage development of the given technique. There are several possibilities. When a technique is first discovered, the scientific community has to examine it. Then, if they agree that it is well founded, it is considered to have been accepted by the scientific community and, therefore, can be admitted into court. Some of the techniques that were evaluated under *Frye*, besides polygraphs, were voiceprints and neutron activation. Neutron activation is the technique of bombarding

specimens with neutrons (a particle found in the nucleus of atoms) and measuring a ray of energy emitted by the nucleus called a gamma ray.

The reasoning for the *Frye* test is that it is necessary to make sure that qualified people will decide if the conclusions of a method are reliable and should be used in court. Sometimes, it can be hard to conclude when a discovery has been accepted and is no longer in the experimental stage. The *Frye* case decided that the blood pressure test was not adequately accepted and recognized. Consequently, the court could not admit the results as scientific evidence.

Since the *Frye* case, in 1923, courts decided to change the test due to the many new advances that the scientific community might not have completely accepted. 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, if (1) the testimony is based on sufficient facts or data, (2) the testimony is the product of reliable principles and methods, and (3) the witness has applied the principles and methods reliably to the facts of the case.

Some of these changes occurred with the case *Daubert v. Merrell Dow Pharmaceuticals, Inc.*, 509 U.S. 579 (1993). In this case, the families of two children born with birth defects sued the company, Merrell Dow Pharmaceuticals, Inc., which made Bendectin, a medication that the mothers took while pregnant. The evidence included testimony from several expert witnesses. One doctor testified, stating that no other birth defects related to Bendectin were seen in studies of over 130,000 patients. On the other hand, some of the plaintiff's witnesses testified that they believed Bendectin could cause birth defects, based on experiments done with animals. The district court ruled in favor of the defendant, stating that scientific evidence is admissible only if the principle on which it is based is "sufficiently established to have general acceptance in the field to which it belongs." This was the standard used in *Frye v. United States*. The Court of Appeals affirmed.

The case went to the U.S. Supreme Court, which disagreed and reversed the lower courts' decisions. It set forth a new standard, which said that the test of admissibility should be whether the testimony includes "scientific knowledge" that was tested, and not only evidence of generally accepted principles.

The Supreme Court's opinion was that since Rule 702 was written after *Frye*, it could overrule the *Frye* standard. It does not require a standard as high as "general acceptance." Therefore, the trial court judge can decide whether the evidence is reliable and should be admitted.

Some of the factors that *Daubert* examined to decide if testimony should be admitted were how well the theory was tested and how reliable it is, whether it was published, whether the expert has a respected position in the scientific community, and whether another expert could use the technique to get the same result.

At this time, the *Daubert* decision is only binding on federal courts. However, many states use it as well. Other states use the *Frye* standard or another standard altogether.

Several years later, *Kumho Tire v. Carmichael*, 526 U.S. 137 (1999), used the *Daubert* standard and extended it to technical evidence, rather than just scientific evidence. That case applied the ruling in *Daubert* to a situation where the testimony was of nonscientist experts, specifically a tire failure expert. This case started when there was a car accident in which the tire of a minivan blew out. The accident led to one death and several injuries. The plaintiff,