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AN INTRODUCTION TO FORENSIC SCIENCE: THE SCIENCE OF CRIMINALISTICS

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CHAPTER 2 **Crime Scene Investigations**

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Chapter 2.1: Crime Scene Evidence

"This is evidence that does not forget. It is not confused by the excitement of the moment. It is not absent because human witnesses are, it is factual evidence, physical evidence cannot be wrong, it cannot perjure itself...only its interpretation can err." Paul L. Kirk (1902-1970) forensic scientist

Learning Goals and Objectives

Crime scene evidence forms a critical core of forensic investigations. Accurate observations and measurements are key to analyzing these data. In this chapter, you will need to understand the following concepts:

- What is meant physical evidence?
- When is evidence admissible in court and what circumstances might render it inadmissible?
- What are class and individual characteristics?
- What types of comparison analyses can be done and when are they used?
- What is meant by probative and prejudicial evidence?

Introduction

What is evidence? In essence, we use forensic evidence to try to connect two things together – a suspect with a crime scene, a weapon to a wound, a computer message with a criminal act, or a poison to a cause of death. Most often, we deal with various types of material evidence - physical items that serve in this key linking role. Ideally, the link between the item of evidence and its source should be unambiguous – evidence linking just one person from among all others with one unique crime scene to the exclusion of all other possibilities – although this level of connection is often not possible. From *Locard's Principle*, we know that when two objects come into contact there is a transfer of material. We *only* need to discover a way to find, collect, and analyze this transferred material in order to establish a bridge between the two objects. But the term “only” in the previous sentence is very deceptive.

Unfortunately, evidence doesn't come with labels at the crime scene indicating that it is relevant to the case at hand. Instead, it is often lost in a sea of “environmental” items that have no particular bearing upon the case. Finding the important and relevant evidence may be like finding the proverbial “needle in the haystack.” The key ingredient is often our ability to recognize that a particular item may have relevance to the case.

On television and in movies, all too often the lead investigator walks into a crime scene or suspect's home and, in a matter of seconds, locates a seemingly inconspicuous piece of matter and utters the famous words “Ah ha! I've found it!”, thereby solving the case and unequivocally linking the suspect with the crime beyond all possible doubt. But, of course, this is fiction, maybe even good fiction, but the world of entertainment is often far from the real world of forensic science. Crime scene investigations take a great deal of hard

Probative vs. Prejudicial Evidence

Relevant evidence: evidence having the ability to make the existence of any fact that is important to the case more probable or less probable (from FRE 401).

Probative: Evidence that has the ability to prove or demonstrate something relevant to the case.

Prejudicial: evidence that pertains to some matter not previously decided (such as a prior conviction) or establishes a preconceived bias in a matter being decided. In some ways, all evidence against someone is prejudicial, but must not be unfairly prejudicial.

work, skill, experience, and insight to find and link the forensic evidence together to arrive at a logical chain of events. It also takes a finely honed ability to observe and perceive important pieces of information among the background “noise” of the location. The proper processing of a crime scene may require many different skills from specialized experts such as anthropologists, medical examiners, entomologists, fingerprint experts, photographers, firearm experts, and many others. Each expert brings to the case a refined set of skills that provides insights into what the evidence can provide to the investigation. In essence, the majority of this book is devoted to showing the value that scientific disciplines can bring to criminal investigations.

At its heart, the value of forensic evidence hinges upon what it can tell the “trier of fact”, in other words, usually the court. Unless the evidence can serve in this informing role, it is legally useless, and is, in fact, typically inadmissible. Evidence must also be more probative than prejudicial - meaning that forensic evidence must “probe” the question at hand to provide unbiased information without unfairly prejudicing or confusing the court. These factors all determine the value of forensic evidence in court proceedings.

In this chapter, we will explore what kinds of information physical evidence can provide along with how it is properly and legally collected – critically important questions if the evidence is ever to be useful in legal actions.

Types of Evidence

Evidence may be anything that is introduced as part of a trial and may take a number of different forms. Physical evidence is generally recognized to be a material object, such as a weapon, fingerprint, or item of clothing. It forms part of the broader world of evidence, however, that encompasses other types of forensic evidence that includes chemical, biological, cyber, linguistic and behavioral evidence. In successive major sections of this book, we will focus upon each of these types of evidence in turn.

Evidence typically can provide two key types of information: identification or comparison.

An **identification analysis** focuses first upon describing in great detail the components or composition of an unknown sample. The goal of this approach is to identify the relevant features of a piece of



Figure 2.1.1. Chemical and biochemical analysis of forensic samples can help identify the material through its chemical and cellular composition

(www.pinewswire.net/2011/04/laser-hole-punch-turns-hair-into-forensic-time-machine/).

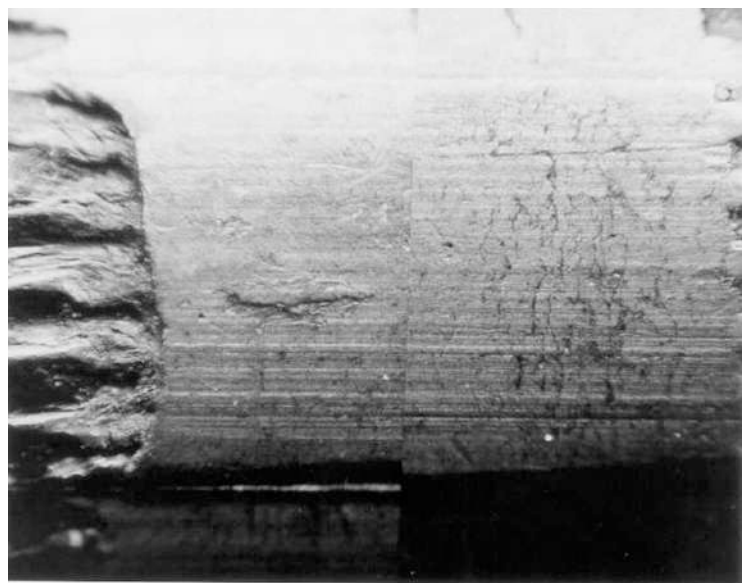


Figure 2.1.2. A comparison of two bullets fired consecutively from a Smith & Wesson 38 Special revolver – note the faint line running down the center of the image separating the images of the two bullets (Science 5 August 2005: Vol. 309, no. 5736, pp. 892 – 895).

evidence with as much specificity and certainty as possible, leading to an unambiguous identification of the material – what the material is (e.g., cocaine, cotton fiber, or lead pipe). For example, the chemical composition of an unknown sample may be required that can be provided by a forensic laboratory analysis (Figure 2.1.1). Samples can come from a material found at a crime scene, scraped from a weapon, wiped from a suspect's hands, or taken during an autopsy. The analysis usually is aimed at determining the specific identity of the substance, such as heroin, glucose or strychnine. In its analysis, the laboratory must carefully consider what type of information is required and how best to obtain useful data. For example, in Chapter 12, we will talk about how light can be used to identify unambiguously the chemical composition of an unknown material to determine if it is an illicit drug, poison or a harmless household compound. Often, multiple methods are employed to verify the correct identification - the more methods that give the same result, the more confident we have are the result itself.

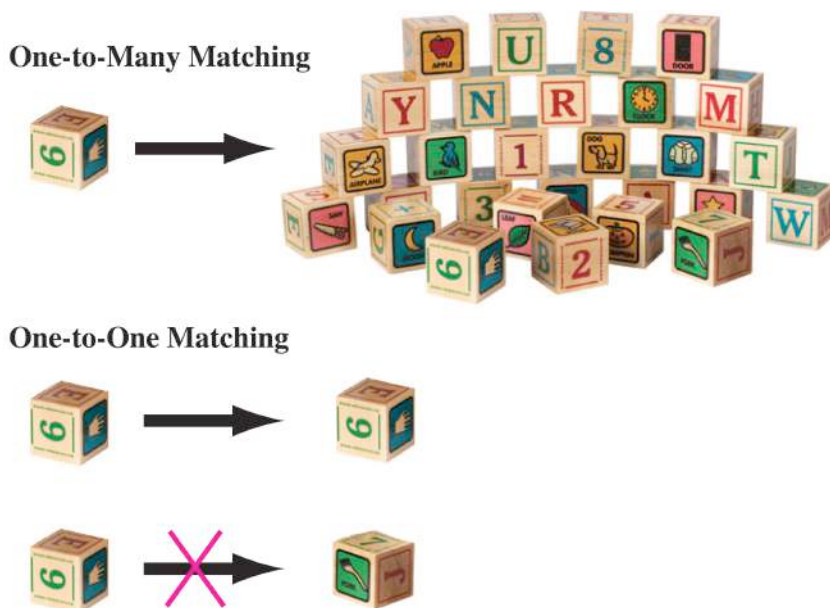


Figure 2.1.3. Difference between one-to-many and one-to-one matching strategies (block picture from: www.naturescrib.com/abc-blocks.html).

Comparison Analysis, in contrast to an identification analysis, tries to associate a standard reference sample (sometimes called an *exemplar*) with a known origin to a sample of unknown origin, usually one found at a crime scene or on a suspect. Specifically, the goal is to determine if the two samples – the exemplar and the unknown - have a common origin. For example, does a hair fiber recovered from a crime scene and a hair sample removed from a suspect have a common source – the suspect's head? Or, does a fingerprint found on a weapon from a crime scene match prints taken by an examiner directly from a suspect? This type of analysis is very common in forensic investigations and is frequently found in the analysis of key types of evidence such as fingerprint, DNA, bullet, bone, pattern and ecological samples such as shown in Figure 2.1.2. The ability to make this type of connection between the sample and the exemplar can help place the suspect at a particular location and either refute or support a hypothesis of a particular chain of events.

Typically, two types of comparison analysis

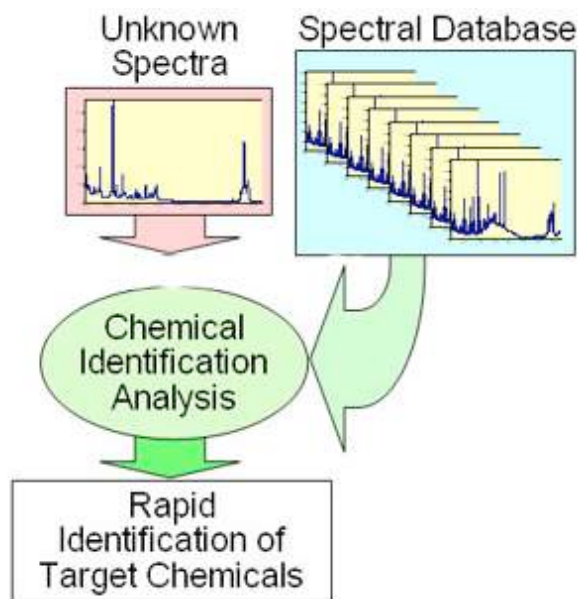


Figure 2.1.4. Chemical analysis by matching the spectrum of an unknown with spectra stored in a database (adapted from www.technet.pnnl.gov/sensors/chemical/projects/ES4RamanSpecAnl.stm).

are frequently encountered. One process involves matching key features found in an unknown sample with candidates from a very large pool of known possibilities, often many millions of records. This type of comparison is called *one-to-many matching*. A very simple example of this is shown in Figure 2.1.3 where one block is compared with many in a set to see if there is a match. In forensic work, this approach might arise when a fingerprint from an unknown person is found at a crime scene or the identity of a set of unknown human remains must be properly identified by DNA. Similarly, a spectrum taken from an unknown chemical can be rapidly compared with a databank of stored spectra of known compounds to rapidly identify the unknown sample by comparison (Figure 2.1.4). This type of analysis is often particularly well suited to a computer-based searching process using a stored database of records. Using a variety of computer search strategies, the features of the unknown are compared to the stored records of those of known origin in the database to find candidate matches. Fingerprints, DNA profiles, eye iris patterns, handgun firing pin patterns, automotive paint profiles, and biometric information are a few of the databases frequently available for this type of searching.

The other type of comparison analysis, sometimes called verification or authentication, focuses upon comparing a set of features observed in an unknown sample with either just one reference sample or among a very small number of “standard” possibilities. The example in Figure 2.1.3 shows a comparison of one “unknown” block with a standard block to see if they match. This process is often referred to as *one-to-one matching*. The process usually involves comparing data from an evidence sample with data from one or a small number of previously recorded reference samples. For example, comparing the scratches on the sides of a bullet found at a crime scene with one test fired from a suspect gun can provide support for that particular gun’s involvement in a shooting (Figure 2.1.2). This type of analysis can also be used as part of a biometrics security scan at an airport (Figure 2.1.5 and 2.1.6) or in determining the identity of return offenders to the criminal justice system.

In any type of comparison, it is important to determine what is the chance

HOW IRIS SCANNERS RECORD IDENTITIES

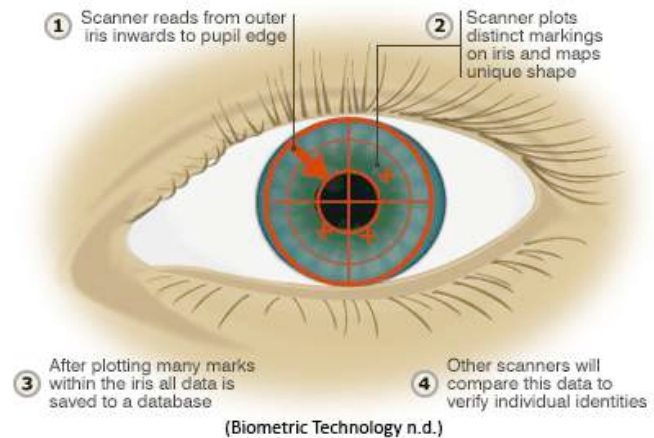


Figure 2.1.5. One-to-one matching process using iris patterns for verifying the identity of a person. The person’s iris is quickly scanned and the pattern is compared to a previously taken iris scan for the individual. If the two “match” the person’s unique identification is verified (<http://mosaic.cnfolio.com/M591CW2010A101>).



Figure 2.1.6. Personal identification authentication on an automated bank teller device using fingerprint recognition to verify a person’s identity by matching the scanned fingerprint at the beginning of the transaction with a reference previously taken from the person and stored in a databank (www.homelandsecuritynewswire.com/topics/authentication-biometrics?page=2).

that a purely random match of the features between two unrelated samples would occur. The more features that a reference sample and an unknown origin sample have in common (without additional non-matching features), the lower the chances of a random match. For example, matching 2 points in fingerprint pattern between two samples may provide a certain, relatively low level of reliability because of the high chance that a random match will occur. Matching 13 points, however, would have a very much higher level of reliability (very low probability of a random match). What is the acceptable number of “matching” data points to determine “beyond a reasonable doubt” depends upon the method used and the consensus of the appropriate scientific community. The more features that match, the more reliable the analysis. For example, matching two loci (places on a chromosome) in a DNA pattern might give a random match rate of 1 in 500 (one in 500 people would have the same pattern at these DNA sites) while matching 13 loci would give a random matching probability of about 1 in 7 trillion. Probability relates to how often a particular event, such as finding a matching feature, will occur. The chances of random matches occurring is governed by the concepts in the field of probability and statistics, something that will be discussed in the following chapter in more detail.



Figure 2.1.7. Class evidence games to use class characteristics to identify a randomly chosen person (<http://tarynmaxwell.com/2008/10/23/mamas-dont-let-your-babies-grow-up-to-be-on-a-board-game/>).

When analyzing evidence, the defining characteristics of a sample dictates what kind of information the analysis can provide. Generally, there are two types of characteristics that evidence may possess: class characteristics and individual characteristics. **Class characteristics** are those that place the piece of evidence within a particular group, such as a lead pipe, or a particular model automobile tire, or type of blood (e.g., AB⁺). **Individual characteristics**, however, relate the sample to a unique and specific origin with a *very high degree of certainty*, such as the fine details found in the pattern in a fingerprint or scratches on a test fired bullet.

Class evidence allows us to place an unknown sample within a smaller subset of items. A very simple example is the children’s guessing game shown in Figure 2.1.7. In this game, each player has the same set of pictures of possible “suspects” placed before them. The goal of the



Figure 2.1.8. Two tires of the same make and model. The model is a form of class information while the damage seen along the right rim of the right tire is a form of individual evidence (www.ehow.com/how_7536688_identify-tire-tracks.html).

Evidence Characteristics

Class Evidence- properties of evidence that can only be connected with a broad group rather than with a specific, unique source.

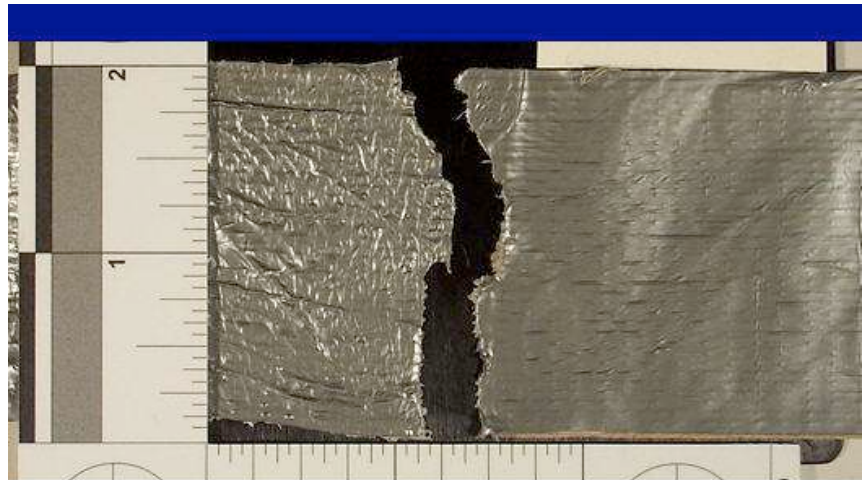
Individual Evidence – properties of evidence that can connect a sample with a specific common source with a high degree or certainty.

characteristics such as all people with glasses or all people with white hair.

Identifying the composition or category of the sample can greatly help to narrow down the possibilities. For example, identifying a pipe sample as a lead pipe eliminates all other types of pipes except lead, such as copper, pvc, aluminum, steel, etc. Or, identifying a piece of broken glass collected as evidence as part of a piece of automobile window glass can be very useful. Even blood typing relies upon class characteristics. For example, about 0.7% of the world's population has type AB- blood. Finding out this information from a very simple blood test can eliminate 99.3% of the population as possible suspects (about 1 in 142 people). Coupling one or more types of class characteristic information can be very powerful. If it could be determined that the criminal was not only AB- blood type but also was a left-handed, red-haired, male, this would further reduce the pool of possible suspects to about 0.0014% or about 1 in 73,000 people.

Class evidence does not, however, usually allow for the direct connection between two individual

game is for the players to figure out the identity of one of the “suspects” drawn at random from the group of “suspects” held by the other player. The players do this by asking each other questions such as “does the person wear glasses” or “does the person have white hair”, to which the other player must respond with either a “yes” or “no” answer. If the answer is no, the player can then eliminate some of the people based upon these features. Through this process, the players effectively place the people into classes of



Physical Fit Between Known (Right) and Questioned (Left) Duct Tape Samples

Figure 2.1.9. Individual characteristics of tear pattern between two pieces of evidence of duct tape shows that they were once a single piece of tape (<http://www.state.nj.us/njsp/divorg/invest/criminalistics.html>).



Figure 2.1.10. Finding a shard of glass from a broken car window in a hit-and-run case can be used to fit into the unique fracture pattern of the windshield

(http://harfordmedlegal.typepad.com/forensics_talk/2006/07/index.html).

items, such as between a crime scene sample and a sample taken from a suspect, with a high degree of certainty. While using class characteristics to eliminate possibilities can be very powerful evidence, it does not provide the one-to-one connection between the evidence and a standard that is often sought after.

Individual evidence, in contrast, usually provides enough distinguishing and unique features to connect two particular pieces of evidence together with a high degree of certainty. For example, two automobile tires can be first placed in a subset using the class characteristics of model, color, and size. Tires can, however, wear differently through use to show unique scratches, marks and other defining features (Figure 2.1.8). Finding a distinctive wear and damage pattern from a tire both in a tire tread mark found at a crime scene the same matching features on an actual tire from a suspect's car can connect the two together with a very high degree of certainty. Pieces of plastic, glass, ceramic, paint, or other "broken or torn" materials can sometimes be pieced back together through their individual characteristics. For example, the unique shapes of pieces of evidence of broken objects can be "fit" back together when placed back in proper alignment to show with a high degree of certainty that they were once originally one continuous object, such as shown for a torn piece of duct tape in Figure 2.1.9. Similarly, a small glass shard found in a victim of a hit-and-run automobile assault can be a vital piece of evidence. Class characteristics can show that the glass came from a typical car windshield but individual characteristics can be used to piece the windshield back together to show that the shard found on the victim fits into the complex pattern of one particular broken windshield (Figure 2.7.10).

These types of evidence have very important roles in legal investigations. But, as mentioned earlier, the evidence, once found, must be properly collected and handled in order to be useful legally. This process will be examined in the next section.