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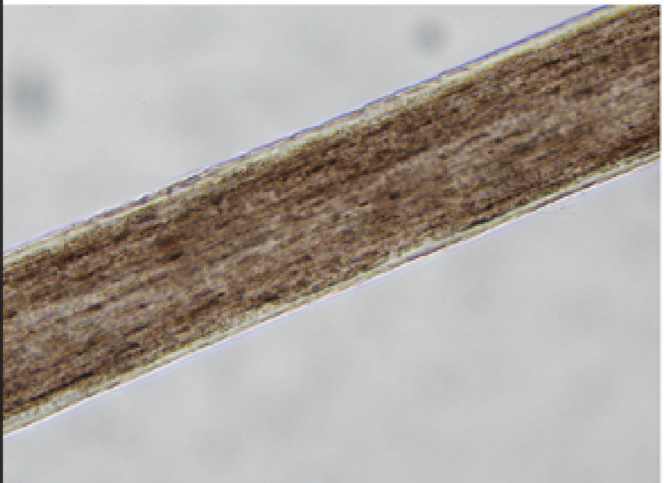
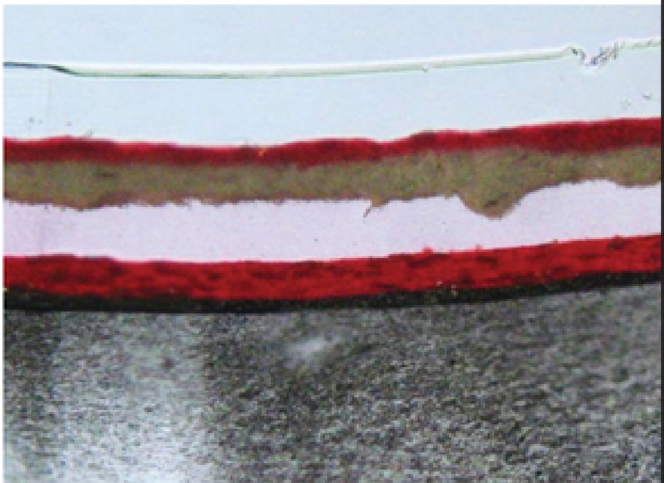
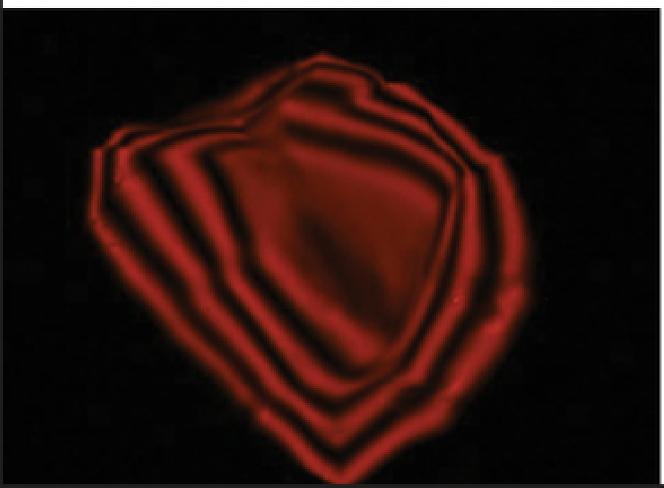
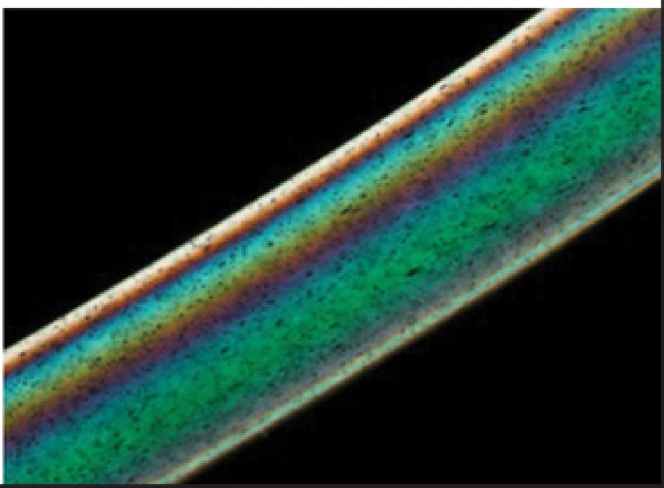
Edited by
Vincent J. Desiderio, Chris E. Taylor and Niamh Nic Daéid

# Handbook of Trace Evidence Analysis

# Handbook of Trace Evidence Analysis

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*Vincent "Vinny" Desiderio: Thank you to my wife Sandi and my two boys, Eric and Ryan, for their unyielding support with everything I have ever or will ever accomplish.*

*Chris E. Taylor: Thank you to my wife, Patricia Caldwell, for her support in my life and professional endeavors. In remembrance of Irving and Joanne Taylor.*

*Niamh Nic Daéid: Thank you to my wonderful girls, Gill, Emily, Molly, and Smudge, for the constant laughs and the joy that you bring.*

*To all trace evidence examiners and trace evidence friends that have supported and continue to support the many disciplines of trace evidence and its value to forensic science, the American Society of Trace Evidence Examiners, and the authors that have contributed their time and knowledge to the creation of this book.*

*Acknowledgments from chapter authors can be found at the end of each chapter.*

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# Preface

The use and application of trace evidence within the forensic sciences is an important component of criminal investigations. Trace evidence can be helpful when attempting to determine if associations exist between suspects, victims, crime scenes, and/or specific objects that may have been involved in the commission of a crime. In addition, when used in the associative context, this type of evidence can also provide a great deal of investigative information. In this latter context, trace evidence can be used to support or to refute the narratives of witnesses, victims, and suspects, to reconstruct events that may have occurred, and to develop potential leads with respect to specific environments from which objects or individuals may have come or traveled to. Notwithstanding this, trace evidence has continued to see a decrease in its use by forensic science service providers across the United States as well as internationally and it is in part the consequent loss of experience and knowledge that this book aims to address.

The idea of this handbook started with a discussion between Vinny and Chris at an American Academy of Forensic Science (AAFS) meeting several years ago. Vinny and Chris were the first and second presidents, respectively, of the recently created American Society of Trace Evidence Examiners (ASTEE). Both had the passion to continue the path to bolster trace evidence resources to the forensic science community. Besides having a society in the ASTEE to bring practitioners together and support information sharing, training, and social interaction, it was believed that to continue the education and development of the future of trace evidence and its practitioners a reference text could be offered.

The AAFS meetings often allow attendees to see and catch up with colleagues and friends, and during the meeting Chris and Vinney also met up with Niamh Nic Daéid, who was at the time with Strathclyde University (now with the University of Dundee). Niamh had made an unsolicited, but as it turned out well-timed, comment that the trace evidence community really needed a reference book. Within a day Niamh invited a friend and colleague from Wiley to meet with the three of us. The Wiley representative was very interested in our initial pitch and invited us to write a book proposal and so the journey that has resulted in this book properly began.

The concept of the book was developed around the need for updated information in the disciplines of trace evidence. No specific dedicated book has been devoted to trace evidence materials in years, making many existing reference texts out of date, particularly in light of the many changes and challenges that have occurred in regards to forensic science over the past decade. These changes have included the increased awareness of validation, modern methods for addressing and controlling contamination, the shift toward incorporating statistical analyses into the interpretation phase, and cutting edge research into new forensic science methods and their application. Criticism of some areas of trace evidence and court room testimony have also occurred and the need for the creation of standards and the development of regulatory bodies have been stressed and highlighted.

We tasked our authors to address several of these challenges in their opening remarks and answer many of the misunderstandings relating to trace evidence. This volume covers many of the foundational trace evidence and forensic science concepts, including having an approach to the collection of materials from scenes which considers the scientific implications, an in-depth chapter on microscopy, and a "first of its kind" chapter on interpretation. The technical chapters chosen include paint and polymers, glass, fibers, and hair analysis.

We selected our authors so as to reach out to current practitioners and academics who are leaders in the field of trace evidence and forensic science. The reader will also see that for many of the chapters the authors have been paired. By partnering a North American author(s) and international author(s) we believe this has broadened and enriched the concepts discussed. Many of the authors have used their networks to gather information for the text and have acknowledged those individual contributions at the end of their chapters. We feel that the collection of authors and their knowledge of the subject areas make this trace evidence resource extremely valuable.

In addition to updating the information on the current practices in trace evidence, the authors were asked, where practical, to discuss suggested workflows in method and testing selections. With the increase in the criticism of forensic science, several of the chapters address the specific scientific challenges and limitations, including the limitations of our knowledge of the transfer, persistence, and background abundance of trace materials. This open approach is one which our authors readily embraced and is something which has been limited or non-existent in previous texts. Addressing the challenges and limitations is critically important to understanding of how trace evidence can still play a significant role in investigations and legal proceedings.

This reference is designed and planned to serve the purpose of both classroom education and as a comprehensive guidance document for entry level examiners. The information provided may also be of use for attorneys and other criminal justice professionals who may need to gain some insight into the practices within the field. Furthermore, the book provides updated information in several disciplines of trace evidence which have not been offered for years.

The final overarching goal of this reference brings us back to the initial concept discussion between Vinny and Chris. In support for the future of trace evidence, this publication demonstrates how trace evidence continues to provide a valuable contribution within forensic science. The recognition and collection of trace evidence materials, its analysis through many technical disciplines, and the interpretation of the analytical findings within the context of a given case have the potential to make significant impact. The importance of this information cannot be stressed enough. If trace evidence materials are never recognized or are destroyed during handling or are never analyzed, then clearly no additional information can be obtained.

We hope you enjoy the collection of chapters in this book and find them useful in understanding the significance of trace evidence analysis and that you find the book to be a valuable reference for your personal or organization's library.

Finally, we are indebted to each and every one of our authors for their patience, dedication, and willingness to so freely share their knowledge and expertise, and provide an invaluable investment into the future generations of forensic trace examiners. We thank also the fantastic team at Wiley for their invaluable help in getting this book over the line and onto the shelves.

Vincent "Vinny" Desiderio
Chris E. Taylor
Niamh Nic Daéid

# 1

# Trace Evidence Recognition, Collection, and Preservation

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## 1.1 Introduction

Trace evidence is often not visible to the human eye, therefore it is typically the least understood and, unfortunately, the most overlooked form of evidence at the crime scene, and surprisingly even within the forensic laboratory. Some police officers, scene investigators, and laboratory personnel have a poor understanding of trace evidence. Proper knowledge is essential so that valuable trace evidence does not become lost, contaminated or accidentally transferred to another surface. Such incidents could severely hinder a successful criminal investigation. The goal of this chapter is to provide a foundation of knowledge that will enable successful processing of trace evidence in the forensic field. The following trace evidence principles will be discussed:

- theories of transfer and persistence
- proper trace evidence handling practices
- recognition, collection, and preservation of trace evidence at the crime scene
- recognition, collection, and preservation of trace evidence in the laboratory.

## 1.2 Theories of Transfer and Persistence

### 1.2.1 Locard's Exchange Principle

Edmond Locard (1877–1966), an early pioneer of forensic science, developed one of its most fundamental principles. His Exchange Principle theorizes that there will be a transfer of material every time contact is made between two surfaces, therefore during the commission of a crime, where contact is inevitable, it stands to reason that there will normally be some transfer of meaningful evidence. It could be in the form of hairs left by the perpetrator, either at the scene or on the victim. It might be fibers from a carpet at the scene or glass from a broken window that was transferred to the perpetrator's clothes. Crime scene events vary greatly and so will the theoretical transfers; thus explaining the difficulty in finding evidence of these transfers.

Another expression of Locard's Exchange Principle is this: When two surfaces make contact, material from one surface is transferred to the other surface and vice versa. Thus, there

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is always a potential for a two-way transfer. At a crime scene, there should (in theory) be material transferred *from the perpetrator to the scene*, as well as material *from the scene to the perpetrator*. In reality, one of these types of transfers is more obvious than the other. Intuitively, it is easier to notice items/materials that may have transferred to the scene because they seem foreign or out of place. It is less obvious to consider what items/materials may have been taken away from the scene. A question that crime scene investigators or laboratory analysts often ask themselves is: "What material was transferred onto the surface of the item I am currently examining?" An area rug at a crime scene provides a good example. It is often not too difficult to see transferred material such as possible blood, broken glass or soil.

The more difficult and sometimes forgotten question has to do with the vice versa aspect of the Exchange Principle: "What may have come into contact with this item and caused a transfer *from* this item to another surface?" In the example of the area rug, there may be fibers from the rug that transferred to the shoes or clothing of any individual who came into contact with the rug. If so, then it is necessary to take known exemplar fibers from the rug. These exemplar fibers would be necessary for a comparison should relevant fibers be recovered from other items in the future.

When finding evidence of one item being transferred to another, there is always the question of what other potential items could have transferred that same material. One of the best trace evidence scenarios occurs when there is a two-way transfer. In other words, when there are indications that trace evidence from one surface transferred to the other surface *and* vice versa. A good example of this sometimes develops in pedestrian hit-and-run collisions. Generally, the victim's clothing is searched for paint chips that may have been transferred from the striking vehicle (the vehicle to person transfer). Conversely, when a suspect vehicle is found, it is typically searched for hairs, fibers or other trace evidence that could have originated from the victim (the person to vehicle transfer). There are many cases in which paint chips are found on the victim's clothing that are similar to the paint on the suspect vehicle and fibers are found on the vehicle that are similar to the victim's clothing. When a two-way transfer such as depicted in Figure 1.1 occurs and there is evidence that each surface/item was involved, the significance of the association is greatly increased.

### 1.2.2 Primary, Secondary, Tertiary, etc. Transfers

Establishing that a transfer may have occurred is only one aspect of trace evidence examination. The *significance* of this transfer can often be difficult to understand. Finding transferred evidence on an item of evidence does not necessarily mean that there was direct contact between the item and the source of the transferred material. The following section describes ways in which trace evidence can be transferred and an understanding of these concepts will lead to better assessments of any trace evidence found at a scene or in the laboratory.

A *primary transfer* occurs when trace evidence from a particular source is deposited directly onto another surface. For example, assume a woman is wearing a sweater composed of orange acrylic fibers that are easily shed. Her husband, who is wearing a blue sweater, gives her a hug. Numerous orange fibers from the wife's sweater are transferred to the husband's sweater. This is a primary transfer, since the transferred orange fibers on the husband's sweater were a result of direct contact with the wife's sweater.

A *secondary transfer* occurs when previously transferred trace evidence is transferred to yet another surface. Using the same example, assume that the husband now enters his vehicle and drives away. When he reaches his destination, he exits the vehicle, leaving some of the previously transferred orange fibers on the driver seat. Now assume that the orange

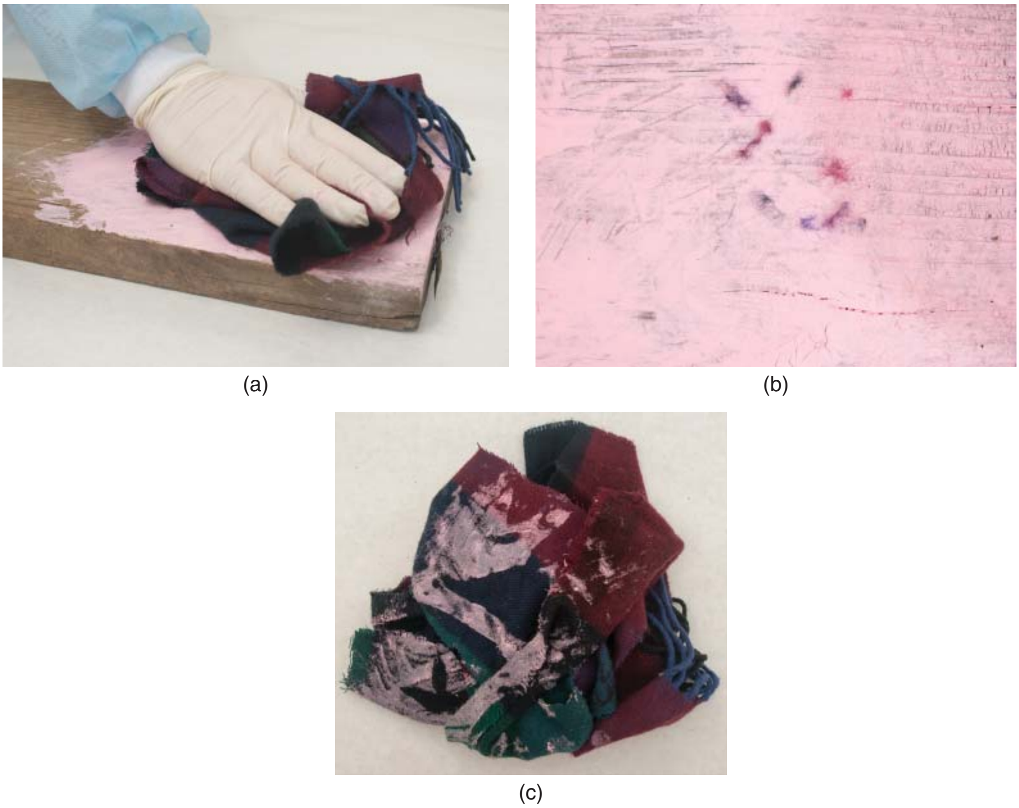



**Figure 1.1** An example of a two-way transfer. (a) An article of clothing being slammed into a board with wet paint. (b) Fibers transferred to the board. (c) Paint transferred to the fabric.

fibers on the seat are compared to known fibers from the wife's sweater. What is the significance of a fiber match in this example? If one did not know that the husband was the driver of the vehicle, it might be theorized that the woman herself was in the driver seat due to the matching orange fibers. The orange fibers in the driver seat, however, were not transferred there as a result of direct contact with the source (the orange sweater), but rather as a result of a secondary transfer from the husband's clothing.

Continuing with the scenario, imagine a man breaking into the vehicle and stealing it. As he sits in the car, some of the orange fibers are yet again transferred, this time to his pants. When he gets to his destination, he exits the vehicle. An examination of his pants would likely reveal orange fibers. Again, there may be an assumption that this individual came into direct contact with the woman's sweater, despite knowing that was not the case. This is an example of a *tertiary transfer*, when evidence is transferred three times: an initial transfer and then twice more. If the car thief re-deposits the orange fibers to yet another surface, that would be considered a *quaternary transfer*, and so on. These examples demonstrate that just because a potential source of trace evidence is established, it does not necessarily mean that two items were in *direct* contact with each other. The concept of multiple transfers should be explained to the police, the lawyers, and/or the triers of fact in a particular case so that they are able to arrive at proper conclusions.

Interestingly, the primary, secondary, and tertiary transfers in the presented scenario all followed Locard's Exchange Principle. However, the key point was whether or not the contact was made with the *original source* of the trace evidence. Only the primary transfer involved the original source (the wife's sweater in the example). Subsequent transfers occurred with other objects which happened to have the *already transferred* orange fibers on them.

### 1.2.3 Non-contact Transfers

While Locard's Exchange Principle deals with contact between two surfaces, not all transfers occur due to direct contact. There are many instances in which trace evidence becomes airborne and then falls onto a surface. Think of breaking a window. Broken glass can travel several feet, potentially landing on any nearby surface (see Figure 1.2). If, for example, there was a jacket on the floor near the window, glass fragments might be deposited. If glass were to be found on the jacket in a subsequent laboratory examination, one might incorrectly conclude that whoever broke the window must have been wearing the jacket at the time.

Numerous types of transfers can occur without direct contact. Shed hairs and fibers, chipping paint, soil dropped or kicked from shoes, and primer and propellant particles from a discharging firearm are additional examples.

**Figure 1.2** A sheet of plate glass being broken by a hammer. The broken glass could potentially land on items several feet away. Source: Courtesy of Keith Mancini, Westchester County Forensic Laboratory.

### 1.2.4 Patterns Due to Contact

The transfer of material that can occur when contact is made between surfaces sometimes results in an impression pattern. Footwear, tires, fabric, and tools are examples of items that have the potential to impart impression patterns. The pattern on the receiving surface corresponds directly to the surface features of the other item. When someone steps onto a floor with a muddy shoe, the mud can transfer to the surface of the floor in a manner that preserves the design of the shoe's outsole (see Figure 1.3). While the mud itself can be useful

(a)

(b)

**Figure 1.3** A muddy shoe (a) and a muddy impression (b).

as soil evidence, the impression pattern of the deposited mud is often of greater importance. If there are indications of deposited material on a piece of evidence, it is important to document it and to determine whether there is an impression pattern present. If so, comparisons can be made between the impression pattern and any item suspected of depositing the material.

Unfortunately, impressions of this type are sometimes missed. For example, an examiner looking for blood on an article of clothing may not realize that the observed reddish material is in the form of a shoe impression. Crime scene investigators and forensic analysts from all disciplines must have an awareness and understanding of impression evidence so that it is not overlooked.

### 1.2.5 Factors Affecting the Likelihood of a Transfer

If it is presumed that every contact results in a transfer of material, why is it that in many instances, even using microscopy, there is no evidence of a transfer? Well, it is possible that, in some instances, transfers do not occur even when contact is made. There are several factors that can affect the possibility of a transfer. Below is a list of some of them:

- The nature of the material being transferred. A wool fiber, which has a rougher surface due to scales, may attach itself to a surface more readily than a smooth surfaced nylon fiber.
- The degree to which the material will shed. Think of polyurethane foam. If it is relatively new and in good condition, the foam probably will not transfer even if contact with another surface is made. On the other hand, if the foam is old, dry, and brittle, it can break away and easily be transferred. Existing damage to a surface may increase the likelihood of a transfer since broken material is not as securely fixed as intact material.
- The nature of the receiving surface. Material will more likely transfer to a sticky surface as opposed to a non-sticky one. Similarly, a fabric that is composed of clingy fibers, such as a wool sweater, will most likely accept material from another surface better than will a smooth fabric, such as a pair of pants made of microfibers.
- The nature of the contact. If two surfaces rub together, there is a better chance of a transfer as opposed to a mere touching of the surfaces. Also, the more force applied during contact, the more likely transfers will occur.
- The number of times contact is made. It seems fairly straightforward that the more times contact is made between two surfaces, the greater the chances of a transfer. For example, assume that there is broken glass on a floor, and someone steps onto it wearing a pair of boots. One step might result in some glass being wedged into the outsole pattern. However, if several steps are made onto the glass, there will most likely be a greater amount of glass transferred.
- The size of the area where contact is made. If a car tire just barely makes contact with a muddy area, there will probably be some soil transferred to the tire. However, if the tire completes a full rotation in the mud, there should be much more transferred soil. Similarly, if someone is wearing a fuzzy sweater and hugs a person wearing another sweater, there will most likely be more fibers transferred than if the person's elbow alone contacted the other sweater.

### 1.2.6 Factors Affecting Persistence

Persistence deals with the following types of questions: What happens to materials once they are transferred to another surface? Will transferred material remain on the item indefinitely? What factors affect the chance that transferred material will remain on an item until the time that the item is examined in the laboratory? Theoretically, the transferred material should remain on a surface until it is transferred again. Ideally, the next transfer will take place when it is properly collected in a laboratory setting. However, due to circumstances such as secondary transfer, there is also the possibility that the material will not be present on the item at the time of analysis. Some factors affecting persistence are listed below:

- The nature of the accepting surface. A clingy sweater should retain transferred material longer than a smooth surface, such as nylon wind pants. If the accepting surface is something that solidifies in time, such as wet concrete, the transferred material will typically remain once the substrate has dried.
- The addition of certain foreign material on the surface. Blood, sap, wet paint, and other materials may be involved in the transfer and aid in keeping material on the transferred surface.
- The nature of the transferred material itself. For example, wet, sticky, irregularly shaped or rough surfaced items will tend to adhere better to a surface than a smooth, solid item such as a shard of tempered glass.
- What, if any, activity occurred after the transfer? Consider, for example, gunshot primer residue. If someone fires a gun, primer residue can fall onto that person's hands. If the primer residue is immediately collected from the hands, there is a good chance that the primer residue will be identified in the laboratory. However, if the person washes or wipes his or her hands, or reaches into a pocket, there is a chance that some, if not all, of the material will be removed from the hands prior to collection. Lifesaving attempts made by medical personnel at the scene can affect transferred trace evidence. Additional activities that can affect the persistence of the evidence include laundering, cleaning, and excessive handling.
- The environment surrounding the items in question. If a particle of material is transferred to a surface outdoors on a windy day, there is a good chance that it could be blown off the surface prior to evidence collection. Similarly, rain will most likely remove previously transferred materials.
- Time is another consideration. As more time goes by, the greater the chance that activity, the environment or degradation can adversely affect the transferred material.
- How deeply embedded the material is on the accepting surface. If a piece of glass is sitting on the very top surface of a carpet in a vehicle, it may be subject to loss or secondary transfer. However, if that same particle of glass is embedded deeply enough into the carpet fabric, there is a good chance that it will remain there for a much longer length of time.
- The force involved during the transfer affects persistence. The force of a speeding vehicle striking a pedestrian can leave an indented fabric impression on the vehicle. Such a transfer will tend to persist through rain, wind, and possibly even light wiping. Embedded fibers may persist and be found within these impressions.

## 1.3 Proper Evidence Handling Practices

When examining or collecting evidence it is important to protect it, prevent its loss, and avoid contamination. Evidence should be handled as little as possible to minimize loss and limit exposure. The most direct and least intrusive techniques should be used. An analyst must be protected from hazardous evidence. In addition, the evidence must be protected from contamination by the analyst. Personal Protective Equipment (PPE) addresses both of these concerns. All evidence has the potential to be hazardous and should always be approached with due diligence and awareness of potential dangers, both physical (sharp edges, dust, debris, pockets concealing weapons) and biological.

### 1.3.1 Proper Clothing to Wear and Why

PPE in the field of forensic science has come a long way. Recall the stereotypical scene of an investigator using a pencil to lift a piece of evidence at the scene. There were no gloves worn. At the time, fingerprints were the only major evidence investigators knew to protect.

With technological breakthroughs and cutting-edge equipment, information is extracted from smaller and smaller samples. Useable DNA profiles can be obtained from a single hair or from flakes of blood and skin. Comparisons are made using millimeter length fibers. So today, investigators and analysts are faced with growing amounts of useful evidence to protect. Fortunately, PPE exists and this section will explain its usefulness.

In order to protect the evidence from analyst contamination, appropriate PPE must be worn (see Figure 1.4). Clean tools and workspaces are quickly compromised when an analyst does not use gloves, a hairnet, mask, etc. The right PPE and laboratory practices will ensure that no analyst "material" is added to the evidence.

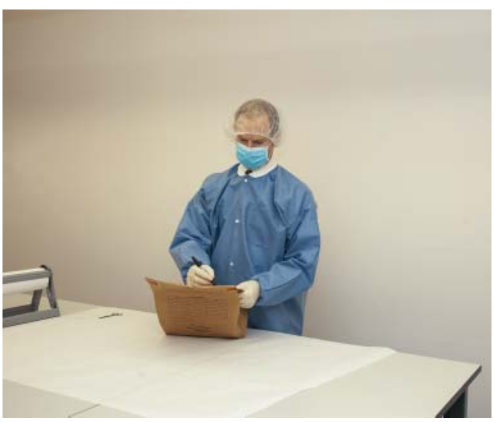


**Figure 1.4** An analyst wearing various items of PPE.

Refer to Table 1.1 for additional information regarding PPE.

PPE should be changed as necessary but definitely when: it becomes soiled, a new case is started, and when working with samples that may become involved in a comparison such as victim and suspect items. PPE should be checked prior to use to ensure that it is intact and in good condition. These steps will aid in avoiding contamination or transfer of materials among evidence items.

### 1.3.2 Other Techniques to Avoid Contamination and Loss

Wet items should be allowed to air dry to avoid mold growth and the inhalation of spores or aerosols. Even when laboratory coats are utilized, wearing garments that shed materials easily should be avoided. If an analyst has a cold or other illness, examination of evidence should be avoided or postponed if possible.

If evidence involves other disciplines besides trace evidence, special consideration of the order of analysis needs to be taken. Analysts from other disciplines should be consulted before any analysis is begun. However, it is ideal for trace evidence to be collected and preserved prior to other analyses.

Questioned evidence should never be brought in contact with known evidence until analysis is completed. For example, questioned fiber evidence should never be brought to a scene to locate potential sources. Instead, photographs and detailed notes should be utilized. Items that can potentially be physically matched to one another should not be brought into contact unless necessary to depict the physical match. Prior to bringing the two items together, the full analysis of the individual items should be completed. Such analysis may include notes, photography, and trace evidence collection.

Appropriate packaging should be used to secure and seal evidence until it can be

**Table 1.1** Proper PPE and reasons for using it.

| Personal protective equipment | Protecting the evidence | Protecting the analyst |
|---|---|---|
| Hair/beard nets | Avoid adding analyst's hair | Avoid materials from evidence getting into analyst's hair |
| Face masks/face shields/goggles | Avoid analyst's breath/saliva from contacting evidence; biological contamination | Protects analyst's eyes and lungs against materials such as mold spores, dust, blood flakes, etc. that may become loose while examining evidence |
| Laboratory coats/ sleeves/aprons | Preventing materials from analyst's clothing being deposited on evidence | Protects analyst's clothing from picking up materials from evidence |
| Disposable gloves | Prevent analyst's skin, sweat, and fingerprints from depositing on evidence | Protect open cuts/wounds and prevent later transfers to eyes, nose, and mouth |
| Booties | Ensure that no erroneous impressions are left behind | No materials are picked up by footwear |

processed to prevent tampering, loss, and/or contamination.

Occasionally, situations of contamination can still arise even when the proper precautions have been taken. Should this happen, document what transpired and communicate with a supervisor or other laboratory advisor. Such actions will help to prevent future occurrences.

## 1.4 Recognition, Collection, and Preservation of Trace Evidence at the Crime Scene

Generally, as a crime is occurring, many events are unfolding. People are moving. Objects are used, moved, and perhaps broken. Blood may be generated from individuals and deposited on surfaces. Numerous transfers of material are most likely occurring. Ideally, the significant transfers will ultimately be discovered and can be vital to the reconstruction of the crime scene.

The perfect situation occurs when the scene is in the exact condition it was immediately following the incident. Unfortunately, this is not always the case. Certain circumstances may affect the preservation and recognition of evidence at the scene. Sometimes this is not the fault of the investigating police or the crime scene analysts. People discovering the crime scene, first responding officers, and emergency personnel are examples of people who can significantly alter the scene. Interviews with people present at the scene and reviews of photographs may reveal what has changed. As this is generally the job of the police, it is important that this knowledge is passed on to crime scene investigators and laboratory personnel who will be examining the evidence.

Even within an unadulterated crime scene, evidence may be missed due to a lack of proper training and/or inadequate standard operating procedures. The crime scene investigation is the first step in the scientific analysis. As such, the investigation should be entirely scientific in approach. Too often investigators at the scene process the scene in a rudimentary way. A scientific approach incorporates elements of the scientific method and becomes the basis for hypotheses regarding various actions that may have been taken during the incident. Since most trace evidence is not visible to the naked eye, it is beneficial to the crime scene investigation to use hypotheses to target potentially significant areas for examination and collection. Further complicating trace evidence examination is the typically overwhelming amount of trace materials present at a scene. Typically only a small amount of that material will prove significant to the event in question.

These areas are best determined by offering hypotheses based on observations and facts gathered during the investigation. Entries, exits, and potential paths of movement within the scene would be considered significant areas for examination and collection.

The areas near and around where the incident took place are perhaps the most significant. Unfortunately, these areas are often the most trampled locations at the scene. Each time someone traverses a relevant pathway through the scene, trace evidence is potentially lost due to secondary transfer and/or other mechanisms. It is therefore crucial that these areas be properly documented and that trace evidence is searched for and collected as soon as possible. Personnel should do their best to limit their presence in and around these important locations.

### 1.4.1 Searching for Relevant Trace Evidence

#### 1.4.1.1 Visible Trace Evidence

Once hypotheses regarding significant areas of interest are made, general searches for evidence can be performed. Grid or quadrant searches can be used to break down a larger area in order to ensure that all areas are searched effectively. If any trace evidence is readily observable at the crime scene, it should be documented thoroughly. Visible items may include paint chips and smears, torn fabric, impressions, broken glass or wood, powders, and other materials. Keep in mind that there may be trace evidence that is not visible. Thus, when documenting and collecting the *visible* evidence, do it in a way that does not disturb the potentially unseen trace evidence. Documentation and collection techniques will be discussed later in this section.

#### 1.4.1.2 Invisible Trace Evidence

Proper lighting is critical to finding evidence at the crime scene. Existing room lights or sunlight are always helpful. A strong flashlight offers versatility as it may be held at various angles while searching. When oblique (side) lighting is required, the flashlight can be held at very low angles, almost parallel to the surface. Impressions, transferred hairs, fibers, and other trace materials are often observed when the light is at a low angle. Turning the room lights off (if indoors) can also be helpful when increased contrast is needed, especially while using oblique lighting.

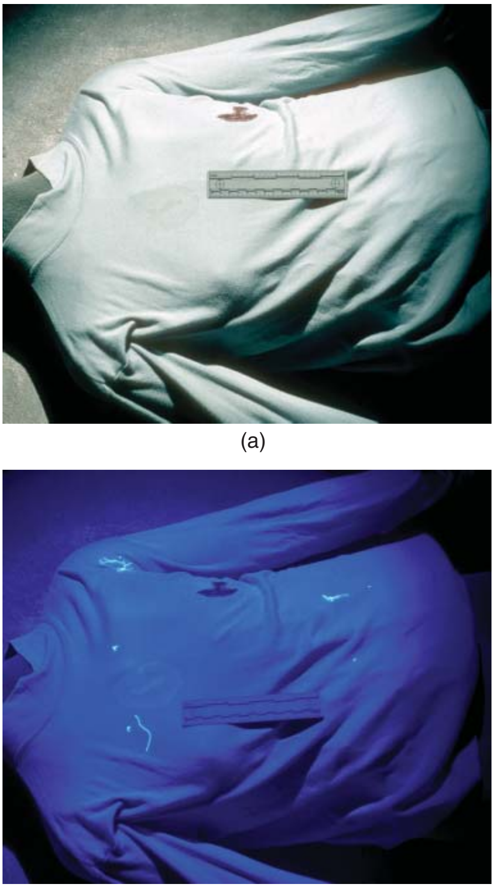
An alternate light source, which is commonly used by biologists looking for stains, works well for trace evidence illumination. In this technique, strong light of selectable wavelengths can be focused onto a surface. The incident light energy induces fluorescence in some types of samples. Goggles of various colors (generally red, yellow or orange) are worn to help visualize the fluorescence. Certain fibers, fragments of glass, minerals, and other particles fluoresce, thus becoming visible with the use of the alternate light source. Even when materials do not fluoresce, the intense light at discreet wavelengths may develop enough contrast to cause trace evidence not previously seen to become visible. Figure 1.5 shows photographs of a shirt in normal room light (a) and with the alternate light source (b).

Trace evidence is often small, therefore the use of magnification is important when searching for it. Using a magnifying glass at the scene can reveal evidence that is not observable with the naked eye. Magnification is especially useful when combined with some of the lighting techniques described above.

Even using the techniques above, some potentially relevant trace evidence may not be observed. The collection techniques that will be discussed later will assist in securing this unseen evidence from the scene.

### 1.4.2 Documentation

Notes, sketches, and photographs are all necessary techniques for documentation at the crime scene. Video may be helpful as well. Some important considerations regarding the documentation of trace evidence at the crime scene



(a)

(b)

**Figure 1.5** Fibers on an article of clothing. A shirt in normal room light (a). The same shirt with the alternate light source (b). Note the fluorescing fibers. Source: Courtesy of Keith Mancini, Westchester County Forensic Laboratory.

will be presented here. Detailed procedures regarding proper overall scene documentation will not be discussed in this book.

Any observed trace evidence should be fully documented with notes and photography; augment with sketches as needed. Notes should include a description of the item and its location. Be sure to mention any special visualization methods that may have been used, e.g. lighting and/or magnification. Note if the material appears to be part of a pattern or if the material is embedded in a substrate. The location of visible trace evidence items should be added to the crime scene sketch and location measurements should be included.

Photographs provide optimal documentation of visible trace evidence at the scene. Actually seeing the origin of important evidence in a case can make an impact on jurors during a trial. Photographs should include, at a minimum, a scale, the case number, and the item number. Medium-range photographs should also be taken to show the item's general location and proximity to other items in the scene. Close-up photographs should then be taken. If the material was only observed with oblique lighting, then, ideally, the flash should be taken off the camera and held at the same angle as when it was best visualized. Similarly, if the evidence was only observed with the alternate light source, attempts should be made to photograph the evidence while using the same alternate light source and a barrier filter matching the color of the goggles used.

As previously mentioned, pertinent trace evidence will not always be visible. Bulk (also known as "blind") collection methods should be conducted to ensure that this invisible evidence is properly secured. Collection techniques, such as vacuum sweeping and tape lifting, will be discussed in the next section. Whatever technique is used, it may eventually become important to the case to be able to indicate the general *area* in which a particular piece of evidence was collected. This can be accomplished with photographs, sketches, and notes.

### 1.4.3 Collection

Remember that no item should be collected without prior documentation.

There are many collection methods for trace evidence. Some methods are mainly used at the crime scene, some mainly in the laboratory, and some can be used in both locations.

Choosing the correct method is not a trivial decision. Some techniques are better in certain situations than others. The collector should be aware of the strengths and limitations of each