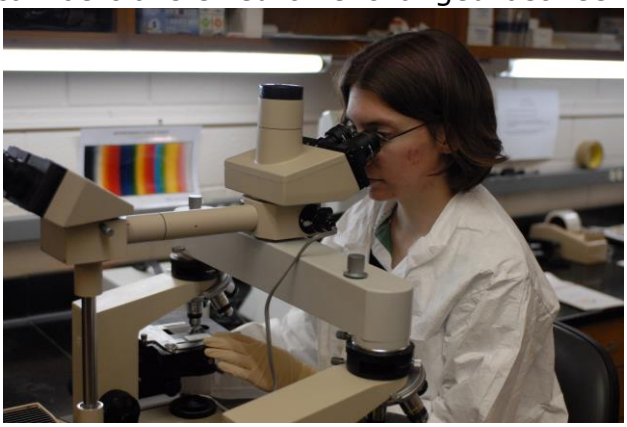
Trace Evidence Overview

The term "trace evidence" is generally thought of as any type of evidence occurring in sizes so small that it can be transferred or exchanged between two surfaces without being noticed. The first scientist to formally articulate a philosophical foundation for transfer-evidence occurrence was the Frenchman, Edmond Locard (1877-1966):



*Wherever he steps, whatever he touches, whatever he leaves, even unconsciously, will serve as silent witness against him. Not only his fingerprints or his footprints, but his hair, the fibers from his clothes, the glass he breaks, the tool marks he leaves, the paint he scratches, the blood or semen he deposits or collects - All of these and more bear mute witness against him. 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 cannot perjure itself; it cannot be wholly absent. Only its interpretation can err. Only human failure to find it, study and understand it, can diminish its value." (*Kirk, Paul L., ***Crime Investigation****,* New York: Interscience Publishers, 1953.*)*

The dust and debris that cover our clothing and bodies are the mute witnesses, sure and faithful, of all our movements and all our encounters.

Trace evidence examinations encompass a wide variety of evidence types that include trace (transfer) evidence, fractured materials (physical matches) and material identifications.

Michael McCarriagher, HQ Trace Section Manager, 404-270-8266

Trace (Transfer) Evidence

This category of evidence includes materials that are often microscopic in nature and are readily exchanged between people, places and objects upon contact. Examples of this type of evidence include hair, fiber, glass, paint and plastic. Examination of questioned and known materials can determine whether samples could (or could not) have the same source of origin.

Fractured Materials (Physical Matches)

It is possible to examine any broken, torn or separated items to determine whether or not they were at one time a single, intact item. This type of examination can determine if evidence did originate from one particular source.

Identification of Unknown Materials (General Materials)

This service provides for the identification of unknown materials not suspected as drug, poisonous, biological or bio-hazardous in nature.

Gunshot Primer Residue

Materials collected from the hands of suspected shooters are examined for the presence of particles of gunshot primer residue.

Trace evidence may not be visible to the naked eye, therefore, special care must be taken to preserve it and prevent loss or contamination. Whenever possible, submit the entire item suspected of bearing trace evidence. All trace evidence must be collected from items at a DOFS laboratory before they are examined or processed for other types of evidence (i.e. latent prints, blood, saliva).

Evidence Submissions

All trace evidence, or items suspected of bearing trace evidence, must be submitted to the laboratory in a sealed and labeled condition or otherwise protected from loss of sample or contamination unless the evidence precludes reasonable likelihood of loss or contamination. Tape that forms a tamper-evident seal or heat-seals are acceptable sealing methods. A proper seal for items being submitted for Trace Evidence examinations is defined as a complete closure that will prohibit the loss or contamination of microscopic evidence. A proper tape seal must extend across the entire opening(s) of the container. Closed envelopes or bags, stapled bags, containers with unsecured lids and short pieces of tape along one portion of a fold do not constitute properly sealed evidence. Please do not use containers with holes,such as commercially available gun boxes.

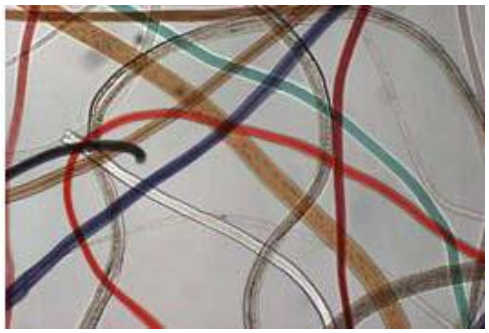
Enclose small items (e.g. hairs, fibers, paint scrapings or glass fragments) in properly labeled and sealed paper pharmaceutical folds. Enclose the paper fold in a sealed outer container such as an envelope or plastic bag. An instructional diagram of a paper pharmaceutical fold can be found at the end of this manual.

Do not put clothing, damp items or items bearing biological evidence in plastic bags. Each piece of evidence must be packaged separately. Exceptions to this would include several broken items from a single crime scene (e.g. broken glass from a single window or broken plastic from a hit-and-run scene). Clothing and bed linens from suspect and victim must be handled and packaged separately to avoid cross contamination. Some trace evidence can remain airborne for long periods of time and cross contamination can occur if extreme care is not taken in the handling of these items. **DO NOT OPEN THESE ITEMS FOR EXAMINATION AT YOUR FACILITY BEFORE YOU SUBMIT THEM TO THE GBI CRIME LABORATORY.**

All items must be clearly labeled with a description of the contents, location where collected, date and time of collection, investigator's name and agency, case number, and exhibit number.

Fibers and Textiles

Fibers can become important evidence in incidents that involve personal contact and struggle. Fiber and textile evidence can provide strong evidence of an association in criminal cases. The individual microscopic fibers that comprise the variety of textile materials in the world can be transferred from person to person and place to place, indicating what environment someone has been in. Examples of such incidents



are homicide, assault, and sexual offenses. In these instances, cross transfers may occur between the clothing of a suspect and victim. Fiber transfers can also occur between people and their environment (e.g. carpeting, upholstery or bedding). The force of impact between a hit-and-run victim and a vehicle may leave fabric impressions, fibers, threads, or even whole pieces of clothing on the vehicle. An intruder entering a broken window may leave fibers on the jagged glass or screen edges. Ropes and cordage from a crime scene can be compared with known samples collected from a suspect. These fibers are compared to suspected sources of origin in the GBI crime laboratory using a rigorous protocol which includes stereo, brightfield, polarized light, fluorescence and comparison microscopy, melting point determinations, Fourier transform infrared microspectroscopy (FTIR) and microspectrophotometry (MSP). Matching fibers between two sources indicate they were in contact. Carpet and upholstery fibers can be recognized as such and can provide information that may aid an investigator in reconstructing a crime or locating a suspect.

It is the job of the forensic fiber examiner to be familiar with all of the different types of fibers on the market and to know which are most commonly used and which are rare. This is often a daunting task as the textile market is constantly changing, but this type of information is critical when discussing how significant a fiber match is during courtroom testimony. Analysis of fibers has played a major role in solving several high profile cases, including the Atlanta murdered and missing children cases in the early 1980's.

Green carpet fibers found on victims were later linked to carpeting found in the home of convicted killer Wayne Williams. The fibers were traced to the manufacturer who provided investigators with information about customers who had purchased that style of carpet.

Fiber examiners also perform examinations to determine if garments have been cut or torn. This becomes important in sexual assault cases where there is a question as to whether the act was consensual or forced.

What to Submit

Cases involving a struggle that has taken place require the submission of clothing from both individuals. Do not handle victim and suspect’s clothing in the same room. Fibers remaining on hands and gloves used to package or examine clothing can cause cross contamination. Keep the victim’s and suspect’s clothing in separate containers. At no time allow them to come in contact with each other. Do not remove clothing after packaging to photograph or examine them. Clothing will not be routinely examined for fiber transfers unless a suspect has been identified or apprehended.

Collection of Fiber Evidence

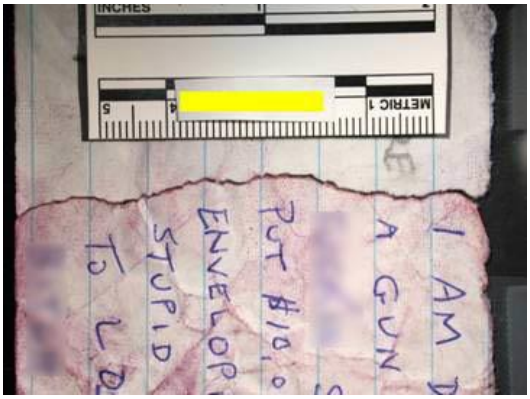
Keep in mind that fibers from the victim’s clothing may still be on the suspect item for quite some time after the incident. Submit the entire item to be

examined. Do not rely on alternate light sources to attempt fiber collection in the field. Many fibers significant to the case will not fluoresce and will be missed. If the entire item cannot be submitted, (e.g. automobile seats or carpet), tape lift the item to collect transferred fibers before collecting a fiber standard. Tape lifts should be placed on clean plastic surfaces for transport (such as the inside surface of a cut open zip-lock bag). Do not place tape lifts on paper or cards, as this may prevent their recovery and comparison. Fiber standards (known samples) should be collected from each source that the victim and suspect are suspected of contacting. Submit the entire item to be used as a fiber standard. If this is not possible, cut a small swatch (i.e. for a car seat) or pull a random sample of the fibers (i.e. for carpeting). When collecting fiber standards from a vehicle, be sure to collect samples from all areas which may have transferred fibers. For example, front and rear floorboard carpeting and mats or front and rear seat upholstery may appear the same but may be manufactured differently from each other. Laboratory analysis may be needed to tell them apart.

DO NOT attempt to remove questioned fiber from clothing unless absolutely necessary to prevent loss. Submit the entire item in a sealed paper bag.

NOTE: The more matching fiber types that exist in a case, the stronger the evidence of association. Remember that fiber matches between two individuals who share the same environment (e.g. live together or drive the same car) are essentially meaningless.

Fracture Match



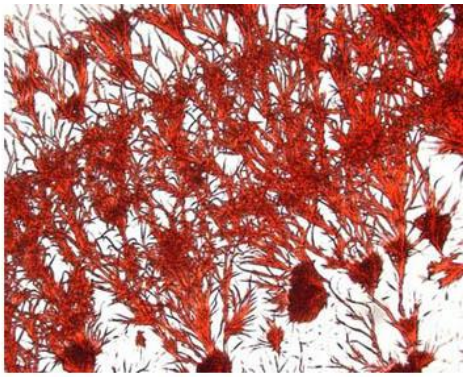
Absolutely any material that is torn, broken or otherwise separated can be examined to determine if two or more pieces were at one time a single piece. Every type of material separates in a unique way and its pieces have the potential to be positively matched back to each other. Evidence submitted to determine if a fracture match can be made is examined for class and individual characteristics. This becomes a truly three-dimensional comparison, focusing not only on the surface characteristics but also on the cross-sectional topology of the fractures. Each fracture will have a unique set of these characteristics and a unique way it will fracture based upon its composition. Examples of materials an analyst can examine are plastic, glass, metal, tape, wood, paper, and fabric.

Pieces collected from different locations must be packaged separately, taking care to avoid any further damage to the fractured surfaces.

Every attempt should be made to submit all the pieces of the broken item.

Care must be taken not to cross contaminate broken items that may have other types of trace evidence on them.

General Materials



These types of examinations are limited to identification or classification of the material. Questioned materials will not be compared with a suspected source of origin.

Examples of materials included in this category are bank security dye packs, fire extinguisher residue, metals, cosmetics and building materials. This list is not all-inclusive, but will include materials that have not been expressly discussed in prior sections.

Glass

The same principles of transfer apply to glass as with other types of evidence and can be used to provide significant information for all types of criminal investigations. A glass analyst can determine whether samples of glass could have originated from the same source by observing a variety of physical, optical and elemental properties of the glass. The physical and optical characteristics would be noted using ultra-violet light, stereomicroscopy, and brightfield/polarized light microscopy. The refractive index and density of the glasses will also be determined. A compositional analysis of the glass is also performed to determine and compare the chemical elements present in the glass. A glass analyst can also determine the direction of force used to break a piece of glass by examining the fracture characteristics of a radial crack once the pieces have been reassembled.

Glass is often encountered as evidence in burglaries, homicides, assaults, and hit-and-run offenses. Examination of glass in the laboratory may reveal:

- Whether questioned fragments could (or could not) have originated from a particular source

- From which side of the glass a force was applied to break it (direction of force)
- Whether broken fragments were at one time a single piece (fracture match)

What to Submit

If the available evidence appears to have potential for a fracture match (physical fit), all pieces of broken glass must be collected and submitted. If the potential for a fracture match is unlikely, all glass evidence found in the possession of the suspect should be submitted. Submit all clothing worn by the suspect. Do not attempt to remove glass from clothing unless absolutely necessary for its preservation. A representative glass standard (known sample) from each broken item (e.g. windowpane, headlight, container) should be submitted for comparison purposes. This comparison glass should always be taken from any remaining glass in the window or doorframe, as close as possible to the point of breakage.

Packaging of Glass Evidence

Questioned and known glass samples must be packaged separately. Glass fragments should be packaged in solid containers to avoid further breakage and/or loss. Sealed boxes, metal tins or heavy plastic bags are appropriate. Clothing should be wrapped in clean paper then submitted in sealed paper bags. Submit entire items suspected of having embedded glass whenever possible (e.g. bats, clubs, weapons).

Direction of Force

The determination of "direction of force" identifies from which side force was applied to break the glass. This may be helpful to determine whether the glass was broken from the inside or the outside. When information regarding the direction of force is needed, all broken glass must be recovered and submitted for analysis. Leave the remaining glass in the window or doorframe intact and mark as to exterior and interior surfaces.

Gunshot Residue

During the discharge of a firearm, escaping gases from the weapon deposit gunshot residue (GSR) on the skin of the shooter's hands, on the clothing of the shooter, and on other objects located in close proximity to the shooter. Included in this gaseous cloud of residue are particles composed primarily of primer residue. Primer compositions may vary with different

types of ammunition and different manufacturers, but the most common constituents of primers have been lead styphnate, barium nitrate, and antimony sulfide. Analysis and characterization of the residue for the trace elements (lead, barium, and antimony) are used to indicate if a suspect has fired, handled, or been in close proximity to a weapon when it was fired.

Gunshot residue kits should be processed as instructed in the kit and sealed with tape. The name of the person or object that was sampled should be written on the outside of the package so that there is no need for opening at the time of submission. Only GSR kits approved by the crime laboratory will be accepted. These are available directly from the manufacturer (kit # GSR-SEM(Q)GBI). The ordering information can be found on the GBI website under the 'Downloads' link at http://gbi.georgia.gov.

Hair Analysis

Hairs collected at the scene of the crime can provide investigative information about the donor when trying to develop a suspect in a case. The average person naturally sheds about 100 hairs a day, which makes it possible that the perpetrator's hair will be found at a crime scene or transferred onto the clothing of the victim. Hair can be transferred from pubic area to pubic area during sexual assaults, or it can be forcibly removed during a vicious struggle. With a microscope and detailed examination, a hair can reveal details about its origin. Examination can reveal whether the hair is animal or human. If the hair is of human origin, the race of the donor and the area of the body from which it originated can be determined. Microscopical examination can also determine if the hair was cut, pulled, naturally shed, if it originated from a living or dead person, if the hair has been subjected to artificial treatments such as bleaching, coloring or permanent waves. Damage due to disease or exposure to fire can also be detected. All this information can be important to the investigators when they know nothing about the perpetrator of a crime.

If a subject has already been identified and it is desired that questioned hairs be compared to the suspect, known hair from that subject will be required to perform a microscopical comparison. Comparison of the questioned hair to the known hair may allow a conclusion that the questioned hair possibly originated from a particular person (support contact between victim and subject). It may also exclude hair as meaningful to the investigation, i.e. hair found on victim is like the victim's own hair. Any significant matching hairs will then be sent to the Biology section for nuclear DNA analysis if the root has follicular material present. If no follicular material is present, the matching hair will be sent to a FBI partner laboratory for mitochondrial DNA analysis.

The transfer of hair can demonstrate contact and association between individuals and objects. In summary, laboratory examination of hair may reveal:

- Whether the source of origin is human or animal
- Race
- Body area of origin
- Artificial treatment
- Condition of hair (e.g. forcibly removed, broken, burned, putrefied)
- Wig fibers
- Whether or not it could have originated from a particular individual. Hairs may be associated with a suspected source of origin through microscopical comparisons and DNA technology.

The following criteria will be utilized to determine whether or not hair evidence will be accepted for analysis:

1. The Trace Evidence Section will analyze hair evidence if other potential sources of DNA have been exhausted (e.g. blood, semen and saliva). OR
2. The Trace Evidence Section will analyze hair evidence if it addresses a critical aspect of the case not addressed by the other sources of DNA (e.g. blood, semen or saliva).

When requesting a hair comparison, known head and pubic hair standards must be submitted from both subject(s) and victim(s) for microscopical comparison by the Trace Evidence Section. A microscopical comparison will be performed to identify hairs that are microscopically like the suspected donor. Those hairs that match microscopically and are suitable will have nuclear DNA testing performed by the Forensic Biology Section. Those questioned hairs that are not suitable for nuclear DNA testing, or that do not yield a nuclear DNA profile will be sent to a FBI partner laboratory for mitochondrial DNA testing.

What to Submit

For those cases that meet one of the above acceptance criteria, known head and pubic hair standards must be submitted from both subject(s) and victim(s) for microscopical comparison. An appropriate known hair sample consists of a minimum of 25 hairs collected randomly from a body area (head or pubic). These hairs must include the root and should be dislodged by combing and then pulling if needed to acquire the minimum number. Do not cut the hair. Do not use forceps to pull hair as it may be crushed-use fingers if needed. Samples from separate body areas must be packaged separately in a sealed pharmaceutical fold or plastic bag and labeled with at least the individual's name and area of body origin. Questioned and known hair from sexual assault victims should be submitted as part of the sexual

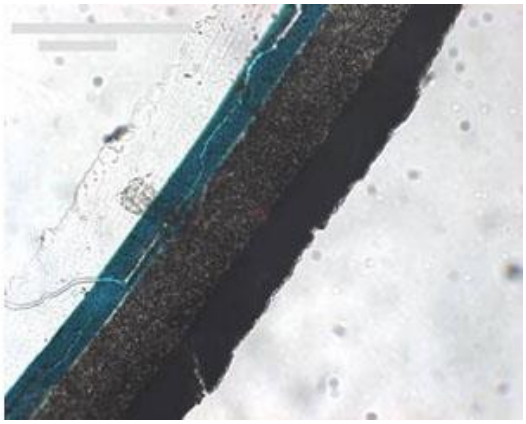
assault evidence collection kit. Known hair from subjects may be submitted as described above or in a GBI hair evidence collection kit. The GBI hair evidence collection kit is available for purchase from Tri-Tech Inc. (Ref. # HC-OGA) at 910-457-6600. The ordering information can be found on the GBI website under the 'Downloads' link at http://gbi.georgia.gov.

It is important that known hair standards be collected as soon as possible to the time questioned hairs were deposited in a case. Hair is a biological entity and its characteristics will change over time, thus complicating or eliminating the effectiveness of a microscopical comparison.

DO NOT attempt to remove questioned hairs from clothing or other items unless necessary to prevent loss. It should be noted that due to potential loss of evidence and possible contamination, **hair examinations will not be performed on items that have been previously examined**. Submit the entire item to the laboratory in a sealed paper bag.

In order to perform further testing through either nuclear or mitochondrial DNA techniques, buccal swabs or blood samples from victim(s) and subject(s) will be required in addition to known hair samples.

Paints and Coatings



Paint evidence occurs as transfers in a variety of crimes, including homicides, vehicular hit- and-runs, sexual assaults, and burglaries. Paint examinations involve either the development of information to aid an investigator or a comparison between a questioned paint sample from a crime scene and a suspected known source of paint. If asked to perform a comparison, the forensic paint examiner will use a variety of microscopical and sophisticated instrumental techniques to reach a conclusion as to whether or not the questioned sample could have come from the suspected object. Furthermore, they will be asked what the significance of the match is. Is the paint unusual in any way? How limited is the group of potential donor sources?

The most challenging task of the paint examiner is the determination of the color, year, make and model of a suspect vehicle that has deposited microscopic bits of paint on the clothing of a hit-and-run victim or on an object at a crime scene. First, the microscopic particles of paint must be located and recovered from the clothing of a victim, and then the paint must be analyzed and compared to reference collections and data bases which catalog what colors and formulations of paint are used by which automobile manufacturers. Just like most other man-made materials, the industry is constantly changing and the efforts needed to keep up with this knowledge

are monumental. The GBI, along with about 100 other crime laboratories across the United States, Canada, Europe, Japan and Australia, contributes to and utilizes a database developed and maintained by the Royal Canadian Mounted Police (RCMP). This database, called Paint Data Query (PDQ) contains chemical and physical information about thousands of paint systems used on vehicles dating back to the early 1970's. This database is the primary tool available to forensic laboratories for use in providing vehicle year, make or model information to the law enforcement community.

Examination of paint in the laboratory may reveal the following information:

- The color of a hit-and-run vehicle and information concerning the year, make and model of the vehicle
- Whether a paint fragment originated from a particular source (physical match)
- Whether paint samples could (or could not) have the same source of origin (comparison of known and questioned samples)

Hit-and-Run Vehicles

There is a potential to physically match chips of paint left at the scene back to the suspect's vehicle. If this potential exists, no paint should be removed from any damaged areas of the vehicle. The questioned paint and the entire suspect vehicle or appropriate panel should be submitted to the laboratory for fracture match examinations. If the potential of a fracture match **does not** exist, samples of transferred (questioned) paint should be taken from each damaged area/panel of the vehicle using a clean, unused blade for each area. Each sample must be packaged separately. Known (standard) samples should then be collected from the original undamaged paint within one inch of each damaged area. Package each sample in a separate pharmaceutical fold, seal it and label the fold. Place the fold in another container (bag or envelope). **Never** use adhesive tape to collect paint samples.

Collection of Paint Standards (Known Samples)

A paint standard is a known sample of the undamaged paint collected from within one inch of a damaged area. Paint may vary in type or composition in different locations on a vehicle or item even though the color appears the same. Therefore, it is important that known paint standards be collected from **each separate panel or area** of the object showing fresh damage using a clean, unused blade for each area. The known standard should contain enough paint to cover the surface of a nickel and must contain all layers of paint down to the substrate. Place each sample in a different paper pharmaceutical fold, seal and label. In addition to investigator's name, date and time of collection, the label must include the specific source of the sample, including vehicle identification number (VIN), if applicable (e.g. "Right front fender, 1996 Chevrolet Blazer, VIN ABC123456789"). The paper fold must be placed in a sealed and labeled envelope or bag. Paint samples must be collected from every vehicle or painted object involved in the

incident, even if some known paint standard is included during the removal of questioned transfers.

Clothing

Do not attempt to remove paint from clothing. Wet clothing must be dried on clean white butcher paper being careful not to lose any microscopic evidence. Package clothing and the paper it was dried on in paper (not plastic) bags.

NOTE: Time is critical in hit-and-run cases requiring investigative lead information. Please submit evidence from hit-and-run victims as soon as practical.

Tools and Other Objects

Tools used to gain entry into buildings or safes often pick up traces of paint as well as other substances such as plaster or safe insulation. Care must be taken to ensure that this evidence is not lost. If such transfers may be present, enclose the end of the tool containing the material in a plastic or paper bag and secure with tape to prevent loss. It is preferable that the entire tool or object be submitted for microscopic examination; however, if the item cannot be submitted, a sample must be obtained. Do not remove paint samples by scraping the surface. Collect the underlying material with the paint. **Never** use adhesive tape to collect paint samples. Remember that tools may also deposit paint onto the surface being contacted. Submit the marked or indented area for trace evidence examination before casts or impressions are made of the toolmarks.

Summary for Collecting Paint Evidence

- Obtain paint from vehicles, walls and similar locations by chipping or carving the paint with a clean scalpel, razor blade or knife.
- Use a clean knife, new razor blade or scalpel for collecting each sample to prevent contamination.
- All layers of paint down to the substrate must be obtained. Place the sample on clean white paper and fold into a pharmaceutical fold, seal with tape, label and place in an envelope or plastic bag. (See diagram for instructions on making a paper pharmaceutical fold).
- Do not place samples directly into envelopes. They will leak.
- Keep each sample collected in a separate sealed container.
- When possible, submit entire object or cut out areas bearing paint smears and transfers.

Plastics and Polymers

Plastics are used in a wide variety of modern products. Vehicle parts, decorative trim tapes, decals, adhesive tapes (duct, electrical, masking, etc.) or rubber may be broken or transferred from one source to another.

Materials such as duct tape, vehicle lenses, trim tape, rubber or anything that is made from plastic can be submitted to the Trace Evidence section for comparison. The techniques used to examine and compare these materials are the same as those used for paints and coatings. However, as with all trace materials, the examiner must have a good understanding of the materials, how they are produced and what variation exists among the products. Vehicle year, make and model information can also be developed from vehicle parts left at a crime scene. A related area of examination includes the comparison of the striations noted on plastic bags. These stria are formed from the manufacturing process and often provide the potential for determining whether or not questioned and known bags were manufactured on the same machine.

Collection and Submission of Plastic Evidence

All plastic evidence must be submitted to the laboratory in an appropriately sealed and labeled condition. The same collection and packaging procedures outlined previously for paint evidence should be used for plastic evidence.

When vehicle parts bearing numbers or markings are recovered from a hit-and-run scene, attempts should be made to have them identified by local auto dismantlers or new vehicle parts department employees. If a part cannot be identified locally, it may be submitted to the laboratory for examination.

Care should be taken with adhesive tape samples to ensure that they don't become entangled or "wadded up". Place strips of tape on platforms made from thick plastic bags (not sandwich bags). These platforms should then be sealed in a paper bag.