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Hairs, Fibers, Crime, and Evidence
Part 2: Fiber Evidence

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Introduction

Placing a suspect at the scene of a crime is an important element in criminal investigation. This can be achieved through the location of textile fibers similar to those from the victim's clothing or the crime scene on the clothing of the suspect, or through the discovery of fibers like those in the suspect's clothing at the crime scene.

Textile fibers can be exchanged between two individuals, between an individual and an object, and between two objects. When fibers are matched with a specific source (fabric from the victim, suspect, and/or scene), a value is placed on that association. This value is dependent on many factors, including the type of fiber found, the color or variation of color in the fiber, the number of fibers found, the location of fibers at the crime scene or on the victim, and the number of different fibers at the crime scene or on the victim that match the clothing of the suspect.

Whether a fiber is transferred and detected is dependent on the nature and duration of contact between the suspect and the victim or crime scene, the persistence of fibers after the transfer, and the type(s) of fabric involved in contact.

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Fiber Evidence

A fiber is the smallest unit of a textile material that has a length many times greater than its diameter. Fibers can occur naturally as plant and animal fibers, but they can also be man-made. A fiber can be spun with other fibers to form a yarn that can be woven or knitted to form a fabric. The type and length of fiber used, the type of spinning method, and the type of fabric construction all affect the transfer of fibers and the significance of fiber associations. This becomes very important when there is a possibility of fiber transfer between a suspect and a victim during the commission of a crime.

As discussed previously, fibers are considered a form of trace evidence that can be transferred from the clothing of a suspect to the clothing of a victim during the commission of a crime. Fibers can also transfer from a fabric source such as a carpet, bed, or furniture at a crime scene. These transfers can either be direct (primary) or indirect (secondary). A primary transfer occurs when a fiber is transferred from a fabric directly onto a victim's clothing, whereas a secondary transfer occurs when already transferred fibers on the clothing of a suspect transfer to the clothing of a victim. An understanding of the mechanics of primary and secondary transfer is important when reconstructing the events of a crime.

When two people come in contact or when contact occurs with an item from the crime scene, the possibility exists that a fiber transfer will take place. This does not mean that a fiber transfer will always take place. Certain types of fabric do not shed well (donor garments), and some fabrics do not hold fibers well (recipient garments). The construction and fiber composition of the fabric, the duration and force of contact, and the condition of the garment with regard to damage are important considerations.

An important consideration is the length of time between the actual physical contact and the collection of clothing items from the suspect or victim. If the victim is immobile, very little fiber loss will take place, whereas the suspect's clothing will lose transferred fibers quickly. The likelihood of finding transferred fibers on the clothing of the suspect a day after the alleged contact may be remote, depending on the subsequent use or handling of that clothing.

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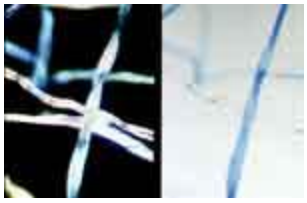
Natural Fibers

Many different natural fibers originating from plants and animals are used in the production of fabric. Cotton fibers are the plant fibers most commonly used in textile materials, with the type of cotton, fiber length, and degree of twist contributing to the diversity of these fibers. Processing techniques and color applications also influence the value of cotton fiber



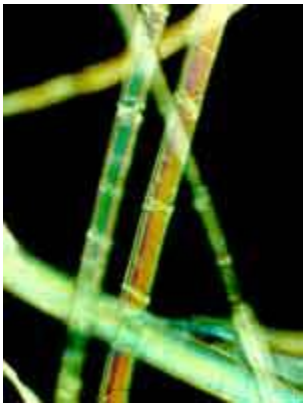
Cotton fibers

identifications.

Other plant fibers used in the production of textile materials include flax (linen), ramie, sisal, jute, hemp, kapok, and coir. The identification of less common plant fibers at a crime scene or on the clothing of a suspect or victim would have increased significance.

Wool fibers

The animal fiber most frequently used in the production of textile materials is wool, and the most common wool fibers originate from sheep. The end use of sheep's wool often dictates the fineness or coarseness of woolen fibers: Finer woolen fibers are used in the production of clothing, whereas coarser fibers are found in carpet. Fiber diameter and degree of scale protrusion of the fibers are other important characteristics. Although sheep's wool is most common, woolen fibers from other animals may also be found. These include camel, alpaca, cashmere, mohair, and others. The identification of less common animal fibers at a crime scene or on the clothing of a suspect or victim would have increased significance.



Flax fibers viewed with polarized light

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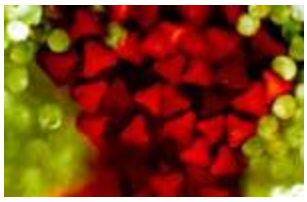
Man-Made Fibers

More than half of all fibers used in the production of textile materials are man-made. Some man-made fibers originate from natural materials such as cotton or wood; others originate from synthetic materials. Polyester and nylon

fibers are the most commonly encountered man-made fibers, followed by acrylics, rayons, and acetates. There are also many other less common man-made fibers. The amount of production of a particular man-made fiber and its end use influence the degree of rarity of a given fiber.



Cross section of man-made fibers

The shape of a man-made fiber can determine the value placed on that fiber. The cross section of a man-made fiber can be manufacturer-specific: Some cross sections are more common than others, and some shapes may only be produced for a short period of time. Unusual cross sections encountered through examination can add increased significance to a fiber association.

Fiber Color

Color influences the value given to a particular fiber identification. Often several dyes are used to give a fiber a desired color. Individual fibers can be colored prior to being spun into yarns. Yarns can be dyed, and fabrics made from them can be dyed. Color can also be applied to the surface of fabric, as found in printed fabrics. How color is applied and absorbed along the length of the fiber are important comparison characteristics. Color-fading and discoloration can also lend increased value to a fiber association.

Cross-sectional views of nylon carpet fibers as seen with a scanning electron microscope

(SEM)

Fiber Number

The number of fibers on the clothing of a victim identified as matching the clothing of a suspect is important in determining actual contact. The greater the number of fibers, the more likely that contact actually occurred between these individuals.

Fiber Location

Where fibers are found also affects the value placed on a particular fiber association. The location of fibers on different areas of the body or on specific items at the crime scene influences the significance of the fiber association.

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Fabrics

Fabric Type

How a fabric is constructed affects the number and types of fibers that may be transferred during contact. Tightly woven or knitted fabrics shed less often than loosely knit or woven fabrics; fabrics composed of filament yarns shed less than fabrics composed of spun yarns. Certain types of fibers also tend to transfer more readily.

The age of a fabric also affects the degree of fiber transfers. Some newer fabrics may shed more readily because of an abundance of loosely adhering fibers on the surface of the fabric. Some worn fabrics may have damaged areas that easily shed fibers. Damage to a fabric caused during physical contact greatly increases the likelihood of fiber transfer.

Fabric Source Determination

When a questioned fiber is compared to fibers from a known fabric source, a determination is made as to whether this fiber could have originated from the known fabric. It is not possible to say positively that a fiber originated from a particular fabric, although the inability to positively associate a fiber with a source in no way diminishes the significance of a fiber association. The wide variety of fiber types, fiber colors, and fabric types can make fiber associations very significant because the value of a fiber association depends on the type of fiber, the color of the fiber, the number of fibers transferred, the location of the recovered fibers, and other factors.

It could be very helpful to know the frequency of occurrence of a particular fabric and fiber, or how many fabrics with a particular fiber type and color exist, as well as who owns them. Such information, however, is extremely difficult to obtain. If the manufacturer of a fabric is known, the possibility exists that the number of fabric units produced could also be obtained, but this information is not always available. How many garments like this still exist, and where they are located, are still in question.

Once a particular fiber of a certain type, shape, and color is produced and becomes part of a fabric, it occupies an extremely small portion of the fiber/fabric population. Exceptions to this would be white cotton fibers and blue cotton fibers like those comprising blue jeans. There are other fibers that are common, but the majority of fibers of a particular type and color constitute a very small percentage of the total number of fibers that exist in the world.

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Fiber Transfer and Persistence

Textile fibers are transferred to the surface of a fabric either by direct transfer (primary transfer) or indirect transfer (secondary transfer). The likelihood of transfer depends on the types of fabric involved in the contact and the nature and duration of the contact. Studies have shown that transferred fibers are lost rather quickly, depending on the types of fabrics involved and on the movement of the clothing after contact. For example, the clothing of a homicide victim would tend to retain transferred fibers for a longer period of time because the victim is not moving.

Emergency personnel, medical examiners, and investigators must handle the victim's clothing carefully to minimize fiber loss. Fibers transferred onto the clothing of an assault victim or onto the suspect's clothing will be lost if the victim and suspect move about, brush the clothing, or wash the clothing. It is difficult to predict precisely how many fibers might remain on the clothing of a living victim or suspect after a given period of time, but it is important for investigators to retrieve and preserve the clothing from these individuals as soon as possible.

Nature of Contact

The type of physical contact between a suspect and a victim can determine the number of fibers transferred and the value placed on their discovery. Violent physical contact of an extended duration will very often result in numerous fiber transfers.

Multiple Fiber Associations

Multiple fiber types found on different items of clothing or fabric from the suspect, victim, and crime scene greatly increase the likelihood that contact occurred between these individuals and the scene. Each associated fiber type is considered to be an independent event and multiple associations undermine a coincidence defense.

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Fiber Evidence: Assigning Significance

Whenever a fiber found on the clothing of a victim matches the known fibers of a suspect's clothing, it can be a significant event. Matching dyed synthetic fibers or dyed natural fibers can be very meaningful, whereas the matching of common fibers such as white cotton or blue denim cotton would be less significant. In some situations, however, the presence of white cotton or blue denim cotton may still have some meaning in resolving the truth of an issue. The discovery

of cross transfers and multiple fiber transfers between the suspect's clothing and the victim's clothing dramatically increases the likelihood that these two individuals had physical contact.

When a fiber examiner matches a questioned fiber to a known item of clothing, there are only two possible explanations:

- The fiber actually originated from the item of clothing, or
- The fiber did not originate from the item of clothing.

In order to say that the fiber originated from the item of clothing, the clothing either had to be the only fabric of its type ever produced or still remaining on earth, or the transfer of fibers was directly observed. Since neither of these situations is likely to occur or be known, fiber examiners will conclude that the fibers could have originated from the clothing or that the fibers are consistent with originating from the clothing. The only way to say that a fiber did not originate from a particular item of clothing is to know the actual history of the garment or to have actually observed the fiber transfer from another garment.

It is argued that the large volume of fabric produced reduces the significance of any fiber association discovered in a criminal case. It can never be stated with certainty that a fiber originated from a particular garment because other garments were likely produced using the same fiber type and color. The inability to positively associate a fiber with a particular garment to the exclusion of all other garments, however, does not mean that the fiber association is without value.

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When one considers the volume of fabric produced in the world each year, the number of garments of a particular color and fiber type is extremely small. The likelihood of two or more manufacturers duplicating all aspects of the fabric type and color exactly is extremely remote. The large number of dye types and colors that exist in the world, coupled with the unlimited number of possible dye combinations, makes any fiber association by color significant. One must also consider the lifespan of a particular fabric: Only so much of a given fabric of a particular color and fiber type is produced, and it will eventually end up being destroyed or dumped in a landfill.

More than 100 billion pounds of fiber were produced in 1998. Approximately 40 billion pounds of cotton were used to produce textile products during 1998 (*Fiber Organon* 1999), and although a great many of these fibers were used in the production of clothing, a large amount of cotton fiber was also used for other purposes, such as stuffing and padding material (batting), cotton swabs, and cotton balls. Much of the cotton used in clothing ends up undyed, as in white shirts, underwear, socks, and bed sheets, but often cotton is dyed many different shades of blue, red, green, and yellow. Much of the cotton fabric produced is also print-dyed, which imparts different color characteristics to the surface of the cotton fibers, and some cotton fabrics are dyed in such a way as to vary the color along the length of the fiber. The cotton fibers in fabrics can remain in a rough state or can be processed in different ways, such as by mercerization.

Figures 1 and 2 display generalized production totals for fabric, cotton, cotton fabric of a specific color, and cotton of a specific color. Although the piecharts depicted in these figures represent ratios of production rather than definitive sums, the significance of a cotton fiber match is evident given the nominal amounts of cotton fabric and colored cotton fibers produced compared to the total quantities of fabric and cotton fibers produced, respectively.

Another important consideration is coincidence. When fibers that match the clothing fibers of the suspect are found on the clothing of a victim, two conclusions may be drawn: The fibers originated from the suspect, or the fibers originated from another fabric source that not only was composed of fibers of the exact type and color, but was also in a position to contribute those fibers through primary or secondary contact. The likelihood of encountering identical fibers from the environment of a homicide victim (i.e., from his or her residence or friends) is extremely remote.

References

Table 2: Worldwide demand for certain fibers: 1994 to 1998, *Fiber Organon* (1999) 70(7): 107.