Chapter 4

A Study of Fibers and Textiles

By the end of this chapter you will be able to:

- Identify and describe common weave patterns of textile samples
- Compare and contrast various types of fibers through physical and chemical analysis
- Describe principle characteristics used to identify common fibers
- Apply forensic science techniques to analyze fibers
Introduction

- Fibers are used in forensic science to create a link between crime and suspect; “circumstantial evidence”
- Through normal activities
  - We shed fibers
  - We pick up fibers
- Very small fibers are classified as trace evidence
- Collecting fibers within 24 hours is critical
- If different fiber types are found on a suspect and also are in common with the crime scene, the more likely it is that the suspect was actually there.
How Forensic Scientists Use Fibers

Fiber evaluation can show

- Type of fiber
- Color
- Possibility of violence
- Location of suspects
- Point of origin

- see list of common questions asked by FS
Sampling and Testing

- Shedding—common form of fiber transfer
- Microscopes reveal characteristic shapes and markings
- Infrared spectroscopy reveals chemical structures to differentiate similar fibers
- Destructive Testing Methods
  - Burning fibers
  - Dissolving fibers in various liquids
Sampling and Testing

**Fiber Burn Analysis Key**

When fiber is removed from flame,

1a. It ceases to burn .................................................. Go to 2

1b. Fiber continues to burn ........................................ Go to 3

2a. Fibers have the odor of burning hair ............... Go to 4

2b. Fibers do not smell like hair ................................. polyester

3a. Fibers produce a small amount of light

   ash residue ...................................................... rayon

3b. Fibers produce a gray fluffy ash ................. cotton

4a. A hard black bead results from burning .......... wool

4b. A brittle, black residue results ...................... silk

Compare fibers found on different suspects with those found at the crime scene
Fiber Classification
—Natural Fibers

Animal fibers (made of proteins):
- Wool and cashmere from sheep
- Mohair from goats
- Angora from rabbits
- Hair from alpacas, llamas, and camels
- Silk from caterpillar cocoons
  (longer fiber does not shed easily)
Fiber Classification
—Natural Fibers

Plant fibers (made of the polymer cellulose):
- Absorb water
- Insoluble in water
- Very resistant to damage from harsh chemicals
- Dissolvable only by strong acids
- Becomes brittle over time
Fiber Classification
—Natural Fibers

Plant fibers:
- Cotton—most common textile plant fiber (picture)
- Coir from coconuts is durable
- Hemp, jute, and flax from stems grow in bundles
- Manila and sisal from leaves deteriorate more quickly
Fiber Classification
—Natural Fibers

Mineral Fibers:

- Fiberglass—a fibrous form of glass
- Asbestos—a crystalline structure
Fiber Classification — Synthetic Fibers

- 50% of fabrics are artificially produced
- Examples:
  - Rayon
  - Acetate
  - Nylon
  - Acrylic
  - Polyester
Fiber Classification
—Synthetic Cellulose Fibers

Regenerated Fibers (derived from cellulose):

- Rayon
  - Most common in this group
  - Imitates natural fibers, but stronger
- Celenese®
  - Cellulose chemically combined with acetate
  - Found in many carpets
- Polyamide nylon
  - Cellulose combined with three acetate units
  - Breathable and lightweight
  - Used in performance clothing
Fiber Classification
—Synthetic Polymer Fibers

Synthetic Polymer Fibers
- Petroleum base
- Very different from other fibers
- Monomers join to form polymers
- Fibers are spun together into yarns
- No internal structures
- Uniform diameters
Fiber Classification
— *Synthetic Polymer Fibers*

- **Polyester**
  - “Polar fleece”
  - Wrinkle-resistant
  - Not easily broken down by light or concentrated acid
  - Added to natural fibers for strength

- **Nylon**
  - Easily broken down by light and concentrated acid
  - Otherwise similar to polyester
Fiber Classification
—Synthetic Polymer Fibers

- Acrylic
  - Inexpensive
  - Tends to “ball” easily
  - Substitute for artificial wool or fur

- Olefins
  - High performance
  - Quick drying
  - Resistant to wear
### Comparison of Natural and Synthetic Fibers

#### Visual Diagnostics of Some Common Textile Fibers under Magnification

<table>
<thead>
<tr>
<th></th>
<th>Cotton</th>
<th>Flax</th>
<th>Silk</th>
<th>Wool</th>
<th>Synthetic</th>
</tr>
</thead>
<tbody>
<tr>
<td>Appearance</td>
<td>Flattened hose appearance</td>
<td>“bamboo stick” appearance</td>
<td>do not taper, yet exhibit small variations in diameter</td>
<td>surface scales may be visible</td>
<td>vary widely in cross-sectional shape and diameter</td>
</tr>
<tr>
<td></td>
<td>Up to 2 inches long tapering to a blunt end</td>
<td>straight with angles but not very curved</td>
<td>may be paired (raw silk) with another fiber</td>
<td>hollow or partial hollow core</td>
<td>generally straight to gentle curves</td>
</tr>
<tr>
<td></td>
<td>may have a frayed “root”</td>
<td>“nodes” are visible every inch or so</td>
<td>no internal structure</td>
<td>fibers up to 3 inches long tapering to a fine point</td>
<td>uniform in diameter</td>
</tr>
<tr>
<td></td>
<td>hollow core not always visible</td>
<td>often occur in bundles of several fibers</td>
<td></td>
<td></td>
<td>may have surface treatment that appears as spots, stains, or pits</td>
</tr>
</tbody>
</table>
Yarns, fabrics, and textiles

- Yarns—fibers (of any length, thick or thin, loose or tight) twisted or spun together
- Blending fibers meets different needs (e.g., resistance to wrinkling)
- Fibers are woven into fabrics or textiles
  - Threads are arranged side by side (the warp)
  - More threads (the weft) are woven back and forth crosswise through the warp
**Weave Patterns**

<table>
<thead>
<tr>
<th>Plain / Tabby</th>
<th>Basket</th>
<th>Satin</th>
<th>Twill</th>
<th>Leno</th>
</tr>
</thead>
<tbody>
<tr>
<td><img src="image1" alt="Plain Tabby Pattern" /></td>
<td><img src="image2" alt="Basket Pattern" /></td>
<td><img src="image3" alt="Satin Pattern" /></td>
<td><img src="image4" alt="Twill Pattern" /></td>
<td><img src="image5" alt="Leno Pattern" /></td>
</tr>
<tr>
<td>- firm and wears well</td>
<td>- open or porous weave</td>
<td>- not durable</td>
<td>- very strong</td>
<td>- open weave (easily distorted with wear and washing)</td>
</tr>
<tr>
<td>- snag resistant</td>
<td>- does not wrinkle</td>
<td>- tends to snag and break during wear</td>
<td>- dense and compact</td>
<td></td>
</tr>
<tr>
<td>- low tear strength</td>
<td>- not very durable</td>
<td>- shiny surface</td>
<td>- different faces</td>
<td></td>
</tr>
<tr>
<td>- tends to wrinkle</td>
<td>- tends to distort as yarns shift</td>
<td>- high light reflectance</td>
<td>- diagonal design on surface</td>
<td></td>
</tr>
<tr>
<td></td>
<td>- shrinks when washed</td>
<td>- little friction with other garments</td>
<td>- soft and pliable</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>- stretches in one direction only</td>
</tr>
</tbody>
</table>
Summary

- Fibers are a form of class evidence.
- Fibers are a form of trace evidence.
- Fibers are spun into yarns having specific characteristics.
- Yarns are woven, with different patterns, into clothing or textiles.
- Fiber evidence is gathered using different techniques.
Summary

- Fibers are analyzed using burn tests, tests for solubility in different solutions, polarized light microscopy, or infrared spectroscopy.
- Fibers are classified as natural or synthetic.
- Natural fiber sources include:
  - Animal hair
  - Plant seeds, fruit, stems, or leaves
  - Minerals.