Unit 6: Introduction to Fiber and Textile Analysis
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**
• 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
Introduction

• **Direct transfer** - fibers may be transferred directly from victim to suspect or suspect to victim.

• **Secondary transfer** - If a victim has fibers on his person that he picked up and then transferred to a suspect.
How Forensic Scientists Use Fibers

- **Type of fiber** – composition, uniqueness, and so on.
- **Fiber color** – often key to matching techniques.
- **Number found** – usually the more found the easier the match.
- **Where found** – can you place the suspect at the scene?
- **Origin (where it came from)** – carpet, upholstery, car, and so forth.
How Forensic Scientists Use Fibers

• **Multiple fibers** – several types of fibers can be more conclusive.
• **Type of crime** – can be the key to fiber transfer (possibility of violence)
• **Time** between crime and fiber discovery – passage of time greatly reduces the effectiveness of fiber evidence.
Types of Fibers

• **Natural fibers** are derived in whole from animal or plant sources.
  • Examples include wool, mohair, cashmere, furs, and cotton.
• **Man-made (synthetic) fibers** are manufactured.
  • Regenerated fibers are manufactured from natural raw materials and include rayon, acetate, and triacetate.
  • Produced solely from synthetic chemicals
  • Examples include nylons, polyesters, and acrylics
Types of Fibers

- **Polymers** or macromolecules, are **synthetic fibers** composed of a large number of atoms arranged in repeating units known as monomers.

**Structure of Monomers and Polymers**

**MONOMER**

A monomer is a small molecule.

**POLYMER**

A polymer is a long-chain molecule made up of a repeated pattern of monomers.
Fiber Classification – Natural Fibers

- **Animal fibers** (made of proteins):
  - Wool and cashmere from **sheep**
    - Wool is the **most common** animal fiber
  - 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
  • 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 Fibers

- Regenerated Fibers (derived from cellulose):
  - **Rayon**
    - Most common in this group
    - *Imitates* natural fibers, but *stronger*
Fiber Classification – Synthetic Fibers

• 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

- 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**
Fiber Classification – Synthetic Polymer Fibers

- 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
Fiber Classification – Synthetic Polymer Fibers

- 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>Cotton</th>
<th>Flax</th>
<th>Silk</th>
<th>Wool</th>
<th>Synthetic</th>
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</thead>
<tbody>
<tr>
<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>
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<tr>
<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>• 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>
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<tr>
<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>
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Comparison of Natural and Synthetic Fibers

• Under magnification, all synthetic fibers have very regular diameters
• Hairs have cuticles
Yarns, Fabrics, and Textiles Oh My!

- **Yarns** - fibers (of any length, thick or thin, loose or tight) twisted or **spun together**
  - Any given yarn will have a **direction of twist**
  - Forensic scientists will identify the twist direction as part of their identification.
Yarns, Fabrics, and Textiles Oh My!

- 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

- **Thread count** - The number of threads that are packed together for any given amount of fabric

<table>
<thead>
<tr>
<th></th>
<th>Plain / Tabby</th>
<th>Basket</th>
<th>Satin</th>
<th>Twill</th>
<th>Leno</th>
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<tr>
<td>firm and wears well</td>
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<td></td>
<td></td>
<td>very strong</td>
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<td>snag resistant</td>
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<td>dense and compact</td>
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<td>low tear strength</td>
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<td></td>
<td></td>
<td>different faces</td>
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<td>tends to wrinkle</td>
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<td></td>
<td>diagonal design on surface</td>
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<td>open or porous weave</td>
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<td></td>
<td></td>
<td>shiny surface</td>
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<tr>
<td>does not wrinkle</td>
<td></td>
<td></td>
<td></td>
<td>high light reflectance</td>
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<tr>
<td>not very durable</td>
<td></td>
<td></td>
<td></td>
<td>little friction with other garments</td>
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<tr>
<td>tends to distort as yarns shift</td>
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<td></td>
<td></td>
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<td>shrinks when washed</td>
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<tr>
<td>not durable</td>
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<tr>
<td>breaks during wear</td>
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<tr>
<td>open weave</td>
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<td>easily distorted with wear and washing</td>
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<td>stretches in one direction only</td>
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Fiber Evidence

• Quality depends on the **ability** of the criminalist to identify:
  - the **origin** of the fiber
  - narrow the **possibilities** to a limited # of sources

• Obviously, if the examiner is presented with fabrics that can be **exactly fitter together** at their torn edges, it is a virtual certainty that the fabrics were of **common origin**
Fiber Evidence

- **Microscopic** comparisons
  - Between questioned and standard/reference fibers
  - Initially taken for **color** and **diameter** characteristics, using a comparison microscope.
Fiber Evidence

• Other **morphological features** that could be important in comparing fibers are:
  • Lengthwise striations on the surface of the fiber.
  • The presence of delustering particles that reduce shine.
  • The cross-sectional **shape** of the fiber.

• Compositional **differences** may exist in the dyes that were applied to the fibers during the manufacturing process.
Sampling and Testing

- **Gathering** evidence
  - Special vacuums
  - Sticky tape
  - **Tweezers**

- **Nondestructive Analysis**
  - **Microscopes** – reveal characteristic shapes and markings
  - Polarizing light microscopy – uses specific wavelengths
  - Infrared spectroscopy - reveals **chemical structures** to differentiate similar fibers
Sampling and Testing

• Destructive Analysis
  • Burning fibers
  • Dissolving fibers in various liquids
• Compare fibers found on different suspects with those found at the crime scene
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
Collection and Preservation

- The investigator’s task of looking for minute strands of fibers often becomes one of identifying and preserving potential “carriers” of fiber evidence.
- Relevant articles of clothing should be packaged carefully in separate paper bags.
Collection and Preservation

- If it is necessary to remove a fiber from an object, the investigator must use clean forceps, place it in a small sheet of paper, fold and label the paper, and place the paper packet inside another container.
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