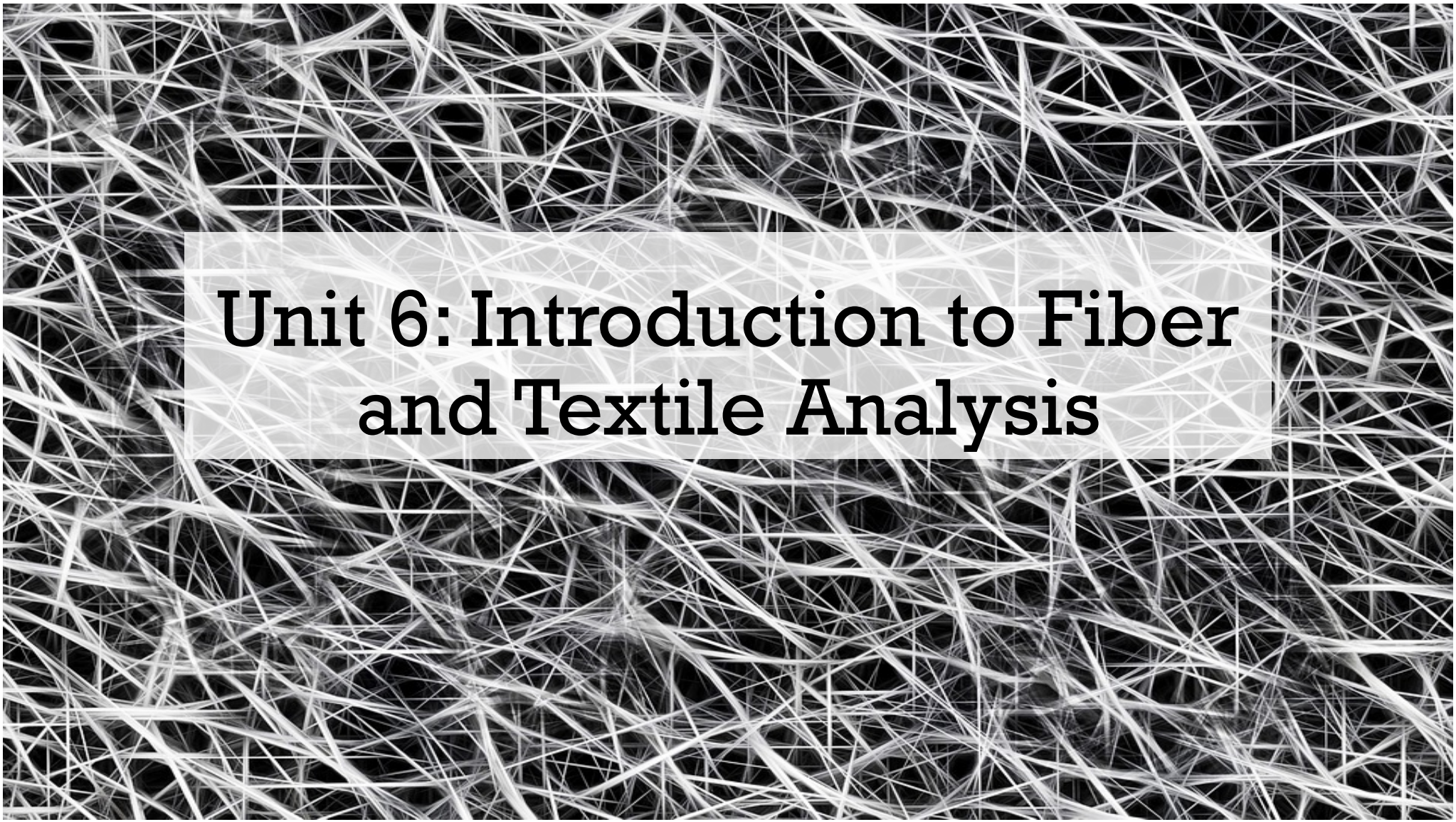


Unit 6: Introduction to Fiber and Textile Analysis

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

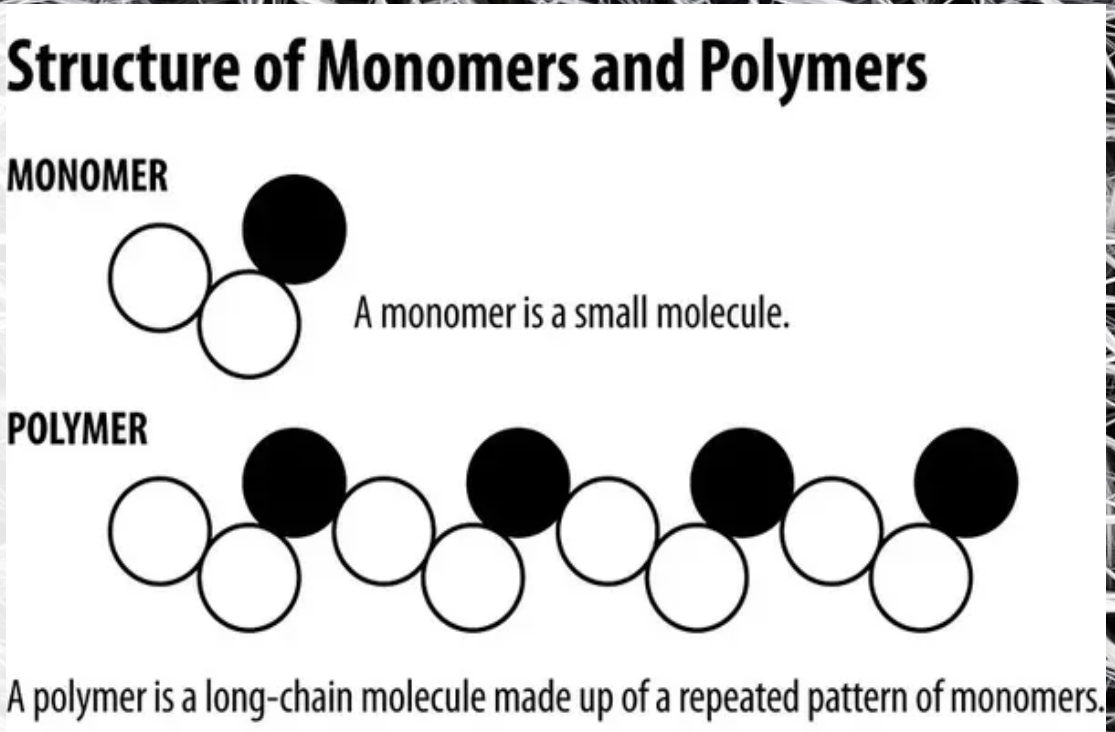
- **Multiple fibers** – several types of fibers can be more conclusive.
- **Type of crime** – can be the key to fiber transfer (possibility of violence)
- **Time** between crime and fiber discovery – passage of time greatly reduces the effectiveness of fiber evidence.

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.

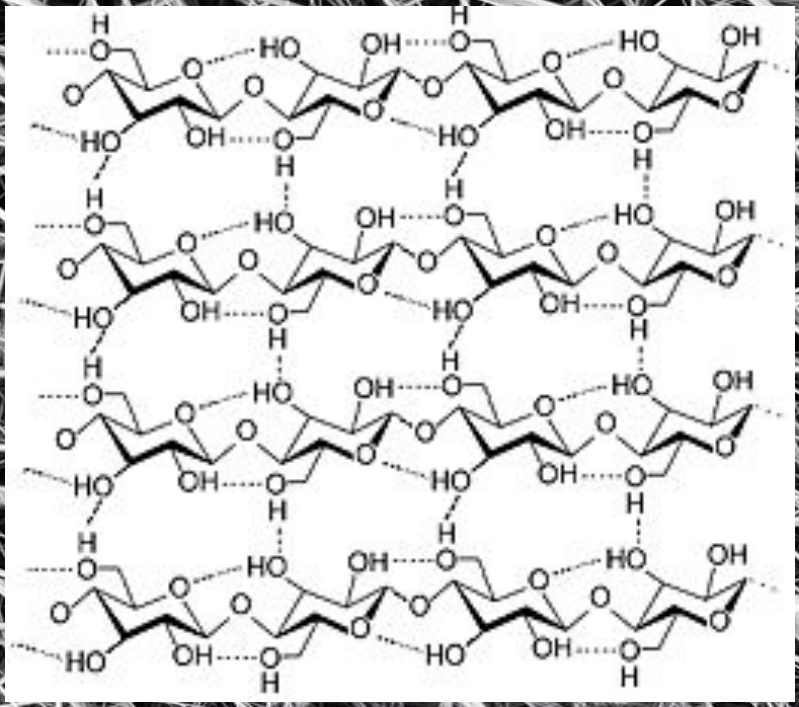


Fiber Classification – Natural Fibers

- **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

- **<u>50%</u>** of fabrics are **<u>artificially</u>** produced
  - Examples:
    - Rayon
    - Acetate
    - Nylon
    - Acrylic
    - Polyester

Fiber Classification – Synthetic Fibers

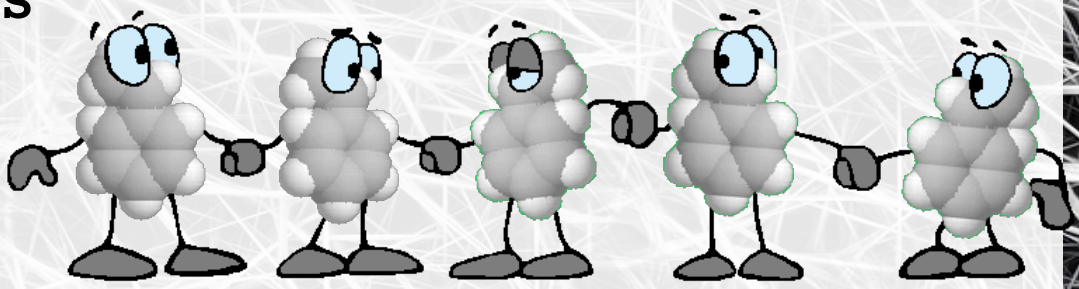
- Regenerated Fibers (derived from cellulose):
- **Rayon**
  - Most common in this group
  - **Imitates** natural fibers, but **stronger**

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

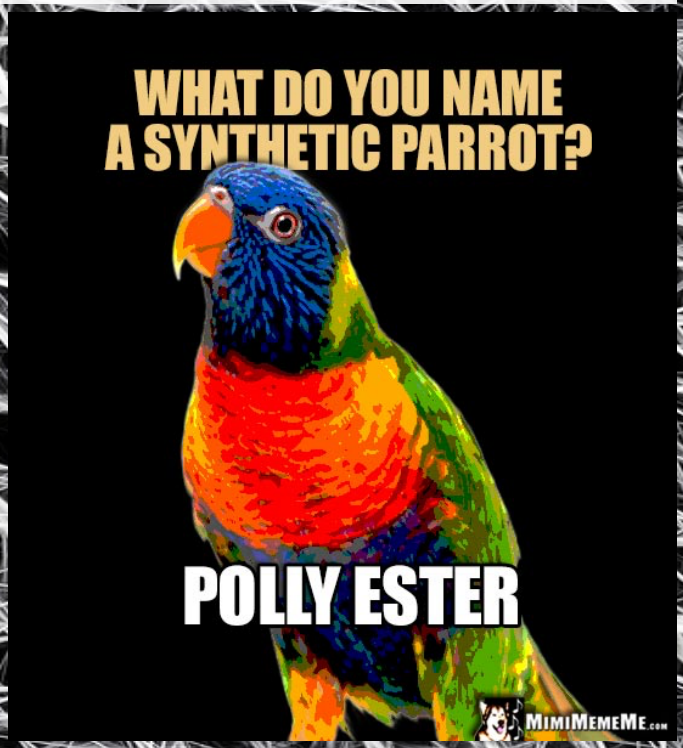
Fiber Classification – Synthetic Polymer Fibers

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



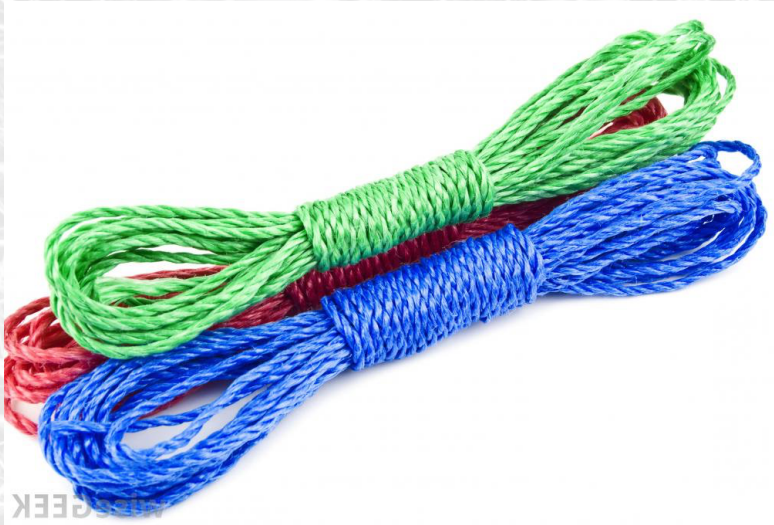
Fiber Classification – Synthetic Polymer Fibers

- 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
  - **<u>Quick drying</u>**
  - Resistant to wear

Comparison of Natural and Synthetic Fibers

Visual Diagnostics of Some Common Textile Fibers under Magnification

Cotton

- Flattened hose appearance
- Up to 2 inches long tapering to a blunt end
- may have a frayed "root"
- hollow core not always visible

Flax

- "bamboo stick" appearance
- straight with angles but not very curved
- "nodes" are visible every inch or so
- often occur in bundles of several fibers

Silk

- do not taper, yet exhibit small variations in diameter
- may be paired (raw silk) with another fiber
- no internal structure

Wool

- surface scales may be visible
- hollow or partial hollow core
- fibers up to 3 inches long tapering to a fine point

Synthetic

- vary widely in cross-sectional shape and diameter
- generally straight to gentle curves
- uniform in diameter
- may have surface treatment that appears as spots, stains, or pits

Comparison of Natural and Synthetic Fibers

- Under magnification, all synthetic fibers have very **regular diameters**
- Hairs have **cuticles**

Yarns, Fabrics, and Textiles Oh My!

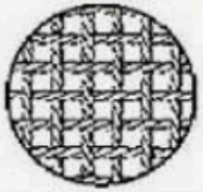
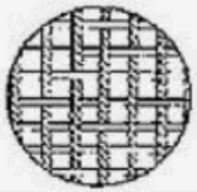
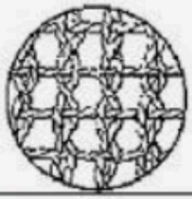
- **Yarns** - fibers (of any length, thick or thin, loose or tight) twisted or **spun together**
  - Any given yarn will have a **direction of twist**
  - Forensic scientists will identify the twist direction as part of their identification.

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 Patters

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

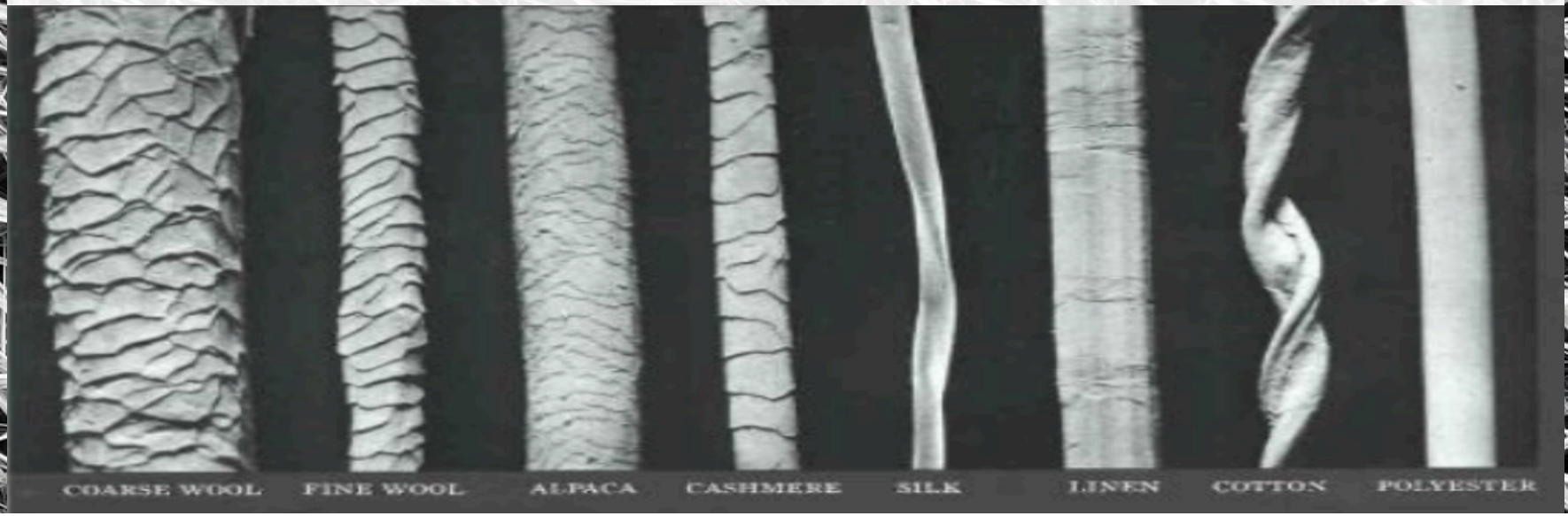
Plain / Tabby	Basket	Satin	Twill	Leno
				
◆ firm and wears well ◆ snag resistant ◆ low tear strength ◆ tends to wrinkle	◆ open or porous weave ◆ does not wrinkle ◆ not very durable ◆ tends to distort as yarns shift ◆ shrinks when washed	◆ not durable ◆ tends to snag and break during wear ◆ shiny surface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

Fiber Evidence

- Quality depends on the **ability** of the criminalist to identify:
  - the **origin** of the fiber
  - narrow the **possiblities** 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 lable 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