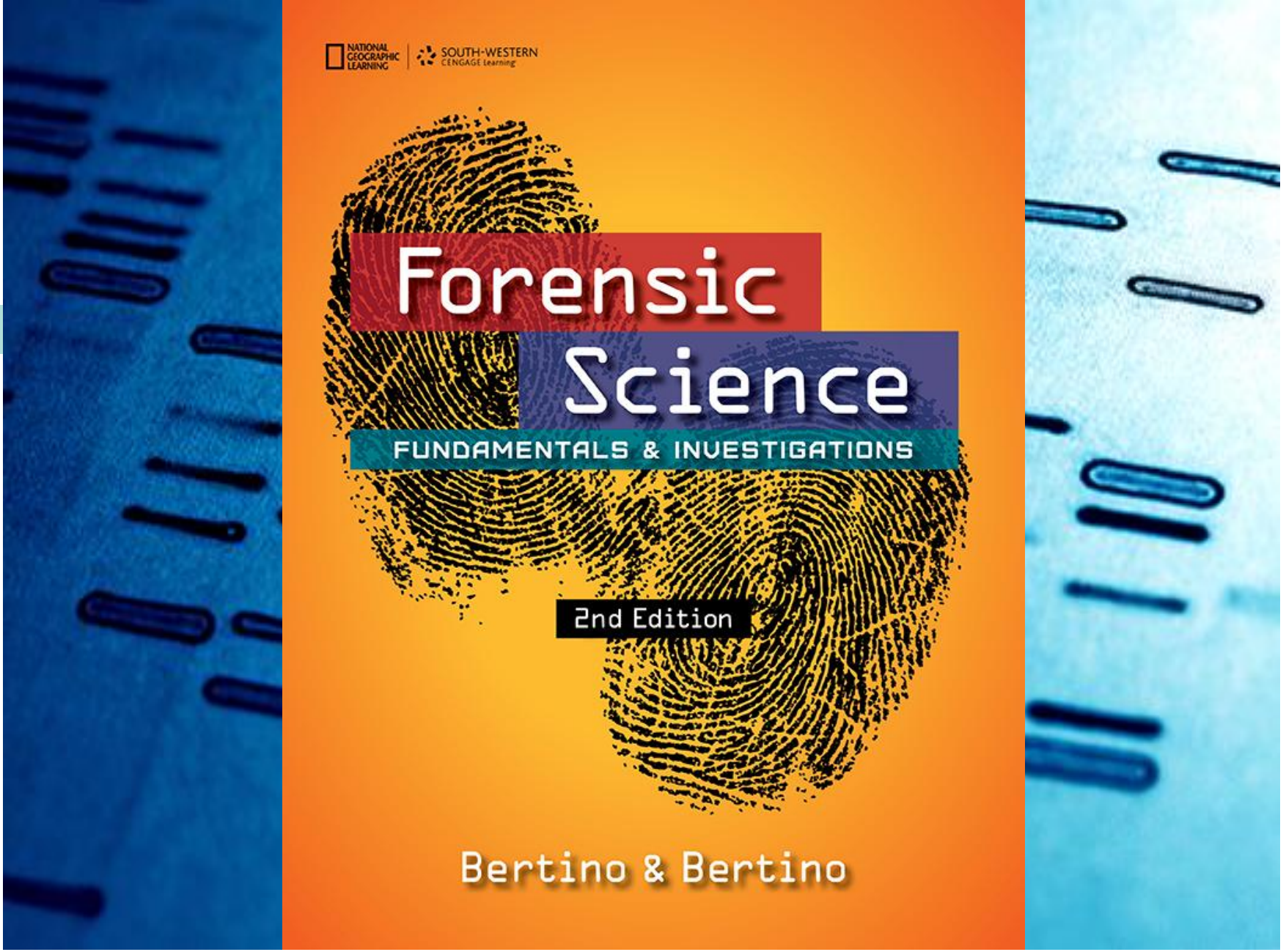


Chapter 4 *A Study of Fibers and Textiles*

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

4.1 Identify and describe common weave patterns of textile samples.

4.2 Compare and contrast various types of fibers through physical and chemical analysis.

4.3 Describe principal characteristics of common fibers used in their identification.

4.4 Apply forensic science techniques to analyze fibers.

Chapter 4
Vocabulary

- amorphous
- crystalline
- direct transfer
- fiber
- mineral fiber
- monomer
- natural fiber
- polymer
- synthetic fiber
- secondary transfer
- textile
- warp
- weft
- yard (thread)

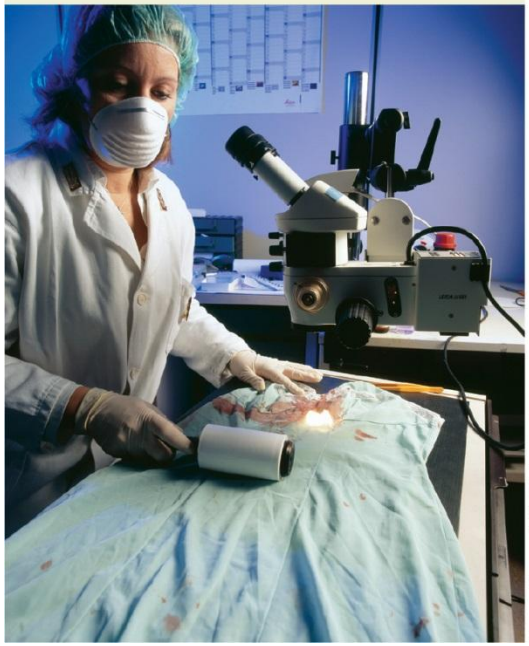
Introduction

- Fibers are used to create a link between crime and suspect.
- not specific to a single person.
- trace evidence.
  - Direct transfer
  - Secondary transfer
- Collecting fibers within 24 hours is critical. (95% lost)

Collecting

- use tape, forceps, a vacuum, or a sticky lint roller.

Figure 4-2 *Collecting fiber evidence.*



Mauro Fermariello/Science Source

Sampling and Testing

- Shedding—common form of fiber transfer
- Microscopic Analysis for natural fibers
- Infrared, florescent, refraction spectroscopy can show chemical structure
- Destructive Testing Methods
  - Burn Analysis
  - Chemical Analysis

Burn Analysis

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

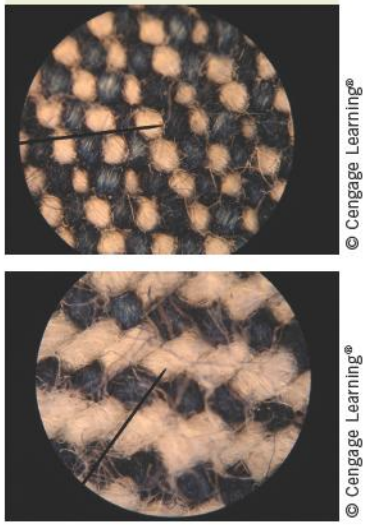
Evaluating

- The value of fiber evidence depends on its potential uniqueness.
  - Type of fiber
  - Fiber color
  - Number of fibers found
  - Where the fiber was found

Evaluating (continued)

- Textile from which the fiber originated
- Multiple fiber transfers
- Type of crime committed
- Time between crime and discovery of fiber

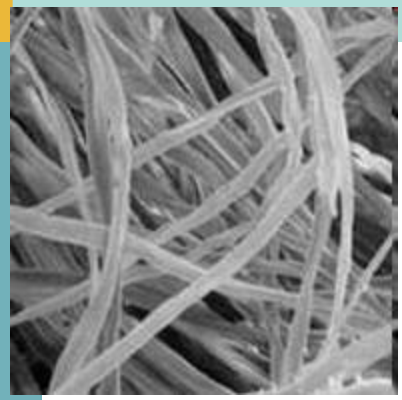
Figure 4-3 *By examining denim (jeans fabric) under a microscope, it is easy to distinguish one pair from another. Also, wear patterns can distinguish two samples.*



Natural Fibers

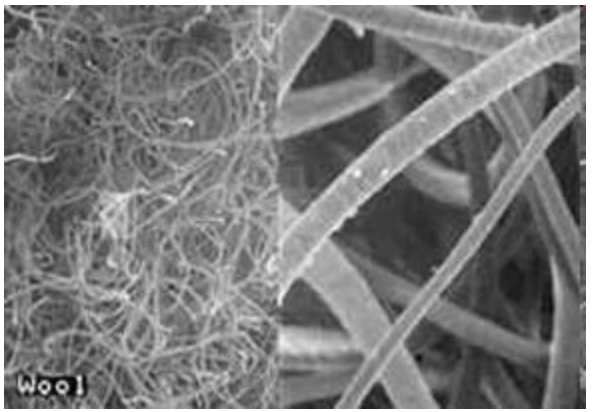
- from animals, plants, and minerals that are mined from the ground.
- composed of polymers, or long, repeating molecules.

Natural Fibers



Cotton fibers are the plant fibers most commonly used in textile materials

The animal fiber most frequently used in the production of textile materials is **wool**, and the most common wool fibers originate from sheep.



http://www.fireflydiapers.com/articles/diaperarticle_naturalfibersabsorb.htm

Animal Fibers

- Three sources: hair, fur, and webbing.
- made of proteins.

Figure 4-4 *Wool fibers can be spun on spinning wheels like this to make yarns.*

Figure 4-5 *Silk cocoons.*

woven wool textile

- Wool / cashmere = sheep
- Mohair = goats
- Angora = rabbits
- Hair from alpacas, llamas, and camels
- Silk from caterpillar cocoons **Bombyx mori**
  (longer fiber does not shed easily)

Plant Fibers

- polymer cellulose.- glucose units.
- can absorb water.
- insoluble in water.
- resistant to damage from harsh chemicals.
- only dissolved by strong acids.
- can be common at crime scenes because they become brittle over time

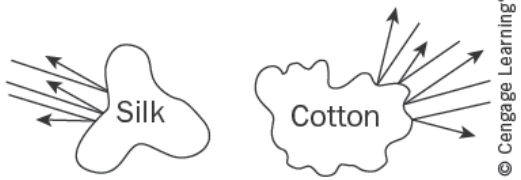
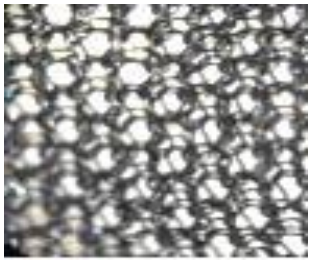


Figure 4-6 *Cross-section of cotton and silk fibers.*

Plant fibers (seed):



- Cotton—most common textile plant fiber (picture)
- Leaf fibers
  - Manila- from abaca plant leaves (banana family)
  - Sisal

- Fruit fibers
  - Coir fiber = coconuts
    - It is relatively waterproof.

- Stem fibers
  - Flax (linen), jute, and hemp

Figure 4-7 *Coir fibers are often used in things like floor mats because they are so durable.*

Susan Van Etten

Figure 4-8 *The rough fibers of jute are made into rope and twine.*

© eleana/Shutterstock.com

- Mineral fibers
  - Fiberglass—a fibrous form of glass
  - Used to insulate buildings
  - Asbestos—a crystalline structure
  - No longer used for building material

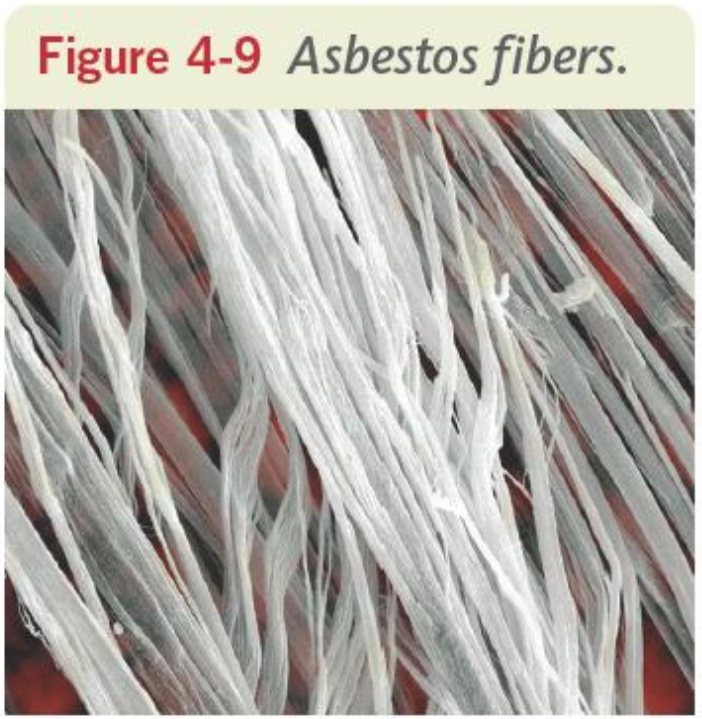
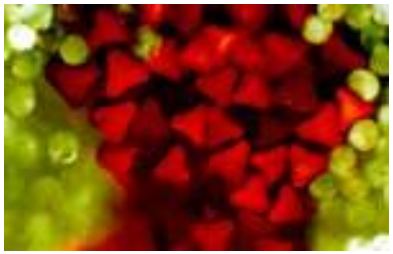


Figure 4-9 *Asbestos fibers.*

Andrew Syred/Science Source

Synthetic (Manufactured) Fibers

- 50% fabrics = man made
  - joining many monomers together to form polymers.
  - Rayon, acetate, nylon, acrylics, and polyesters



Synthetic Fibers under a microscope

Regenerated Fibers (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

Synthetic Polymer Fibers

- Petroleum base
- Fibers produced spun into yarns
- No internal structures- under microscope show uniform diameters

- Polyester
  - "Polar fleece" (Polyethylene terephthalate (PET))
    - First made to mimic wool
  - 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

- Acrylic
  - Inexpensive
  - Tends to “ball” easily
  - Substitute for artificial wool or fur
  - made from a polymer (polyacrylonitrile)
- Olefins
  - High performance- wallpaper, rope, vehicle interiors
  - Quick drying/ Resistant to wear
  - Made from polyolefin (polypropyleneor polyethylene)

Comparison of Natural and Synthetic Fibers

- Synthetic fibers are stronger than the strongest natural fibers.
- Manufactured fibers are not damaged by microorganisms.
- Manufactured fibers can deteriorate in bright sunlight and melt at a lower temperature than natural fibers.

Yarns

- Fibers too short in their raw state to be used to make textiles may be spun together to make yarns.
- Very thin yarns are often called threads.
- For identification analyze twist direction of yarn.

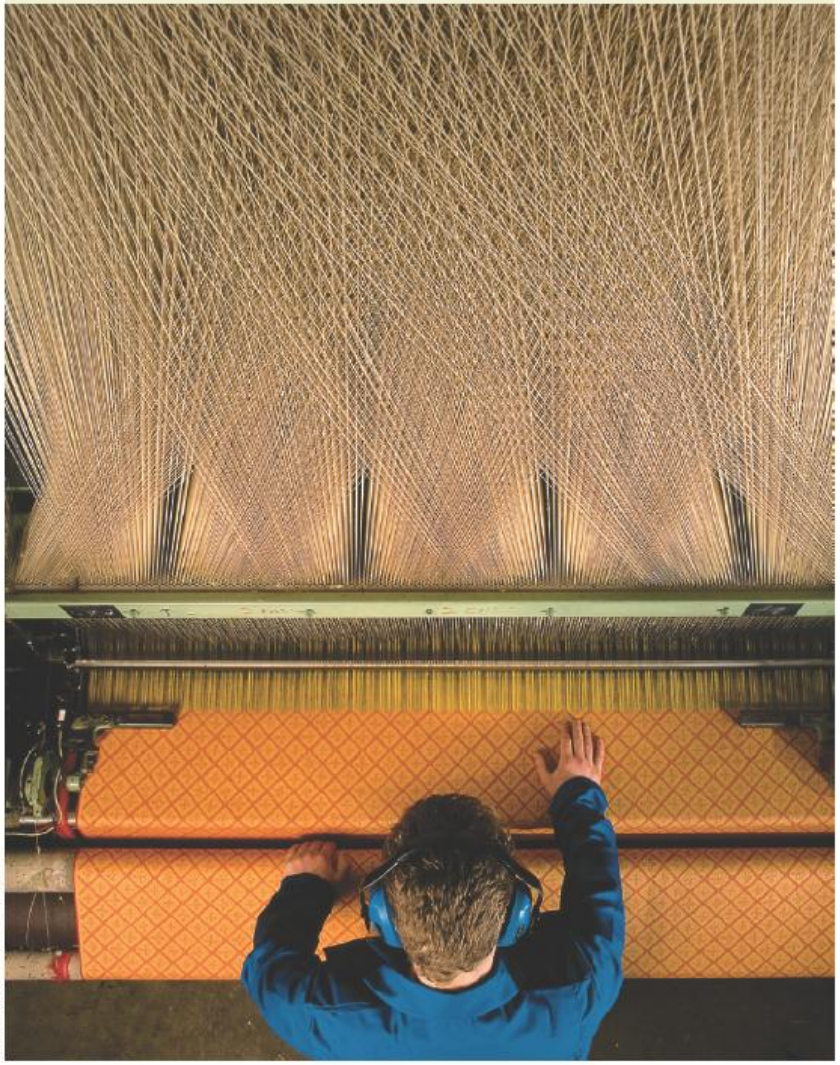
Figure 4-11 *Descriptions of some common fibers.*

Descriptions of Fibers				
Fiber	**Source**	**Characteristics**	**Composition**	**Uses**
Cotton	Plant (seed)	Flattened hose appearance; up to 2 inches long, tapers to point; may have frayed root; twist to fiber; hollow core not always visible; smells of burning leaves; helix-shaped fibers	Cellulose polymer; 19 different amino acids, including cysteine; contains double sulfur bonds; absorbs water but not soluble in water	Many types of textiles
Linen	Plant (flax stem)	Short brittle fibers but longer than cotton; smooth, shiny, resists wear	Cellulose polymer; highly crystalline; resists rot and light damage	Clothing; bed linens; tablecloths
Jute and hemp	Plants (stem)	Dense, strong fiber	Cellulose polymer; highly crystalline, resists rot and light damage	Jute: twine, rope, mats; Hemp: clothing
Manila	Plant leaves (abaca plant)	Long fibers; quickly deteriorates	Cellulose polymer	Garden twine
Wool	Animal (sheep)	Helix-shaped; smells of burning hair when burned	Polymer of keratin with 19 different amino acids; includes amino acid cysteine; contains double sulfur bonds; noted for warmth	Clothing, blankets
Silk	Silkworm cocoon	Triangular fibers; reflects light; glossy appearance	Long fiber	Clothing, bedding
Asbestos	Mineral	Short, weak, brittle	Fiber form of glass	Insulation
Manufactured	Regenerated polymers	Melt at lower temperature than natural fibers	Varied; some made with cellulose; some made with petroleum products	Clothing, bedding, towels, carpets

Textiles

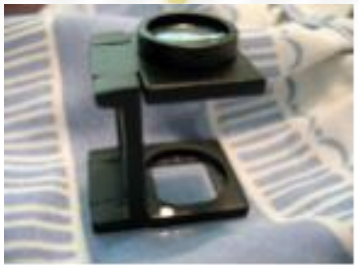
- Weaving consists of arranging lengthwise threads (the warp) side-by-side and close together.
- Cross wise threads (the weft) are then woven back and forth in one of several different patterns.

Figure 4-12 *An industrial loom used to weave textiles.*



ImageState/Jupiter Images

Comparison of Natural and Synthetic Fibers



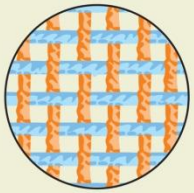
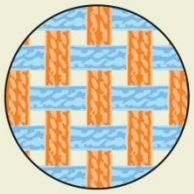
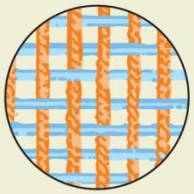
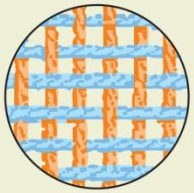
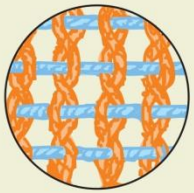
Visual Diagnostics of Some Common Textile Fibers under Magnification

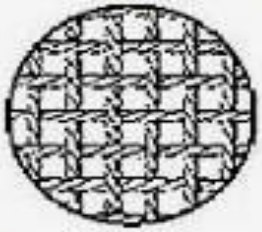
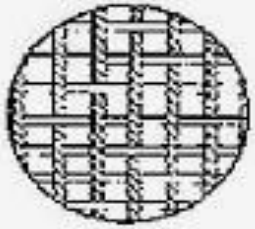
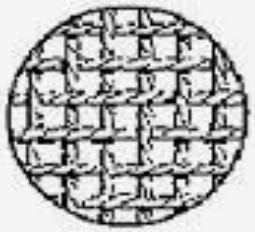
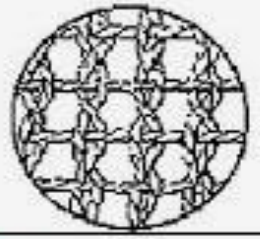
Cotton	Flax	Silk	Wool	Synthetic
◆ Flattened hose appearance ◆ Up to 2 inches long tapering to a blunt end ◆ may have a frayed "root" ◆ hollow core not always visible	◆ "bamboo stick" appearance ◆ straight with angles but not very curved ◆ "nodes" are visible every inch or so ◆ often occur in bundles of several fibers	◆ do not taper, yet exhibit small variations in diameter ◆ may be paired (raw silk) with another fiber ◆ no internal structure	◆ surface scales may be visible ◆ hollow or partial hollow core ◆ fibers up to 3 inches long tapering to a fine point	◆ 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

Textiles (continued)

- The ways that fabrics differ include:
  - Weave pattern
  - Thread count
  - Two ply
- Fiber identification using various microscopes, gas chromatography, and mass spectrometers is possible.
- Fiber identification provides class evidence only and should not be used to convict someone.

Figure 4-13 *Weave patterns.*

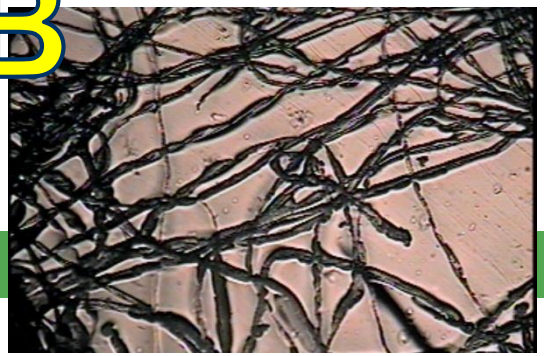
Type of Weave	Diagram	Description	Characteristics
Plain		Alternating warp and weft threads	• Firm and wears well • Snag resistant • Low tear strength • Tends to wrinkle
Basket		Alternating pattern of two weft threads crossing two warp threads	• An open or porous weave • Does not wrinkle • Not very durable • Tends to distort as yarns shift • Shrinks when washed
Satin		One weft crosses over three or more warp threads.	• Not durable • Tends to snag and break during wear • Shiny surface • High light reflectance • Little friction with other garments
Twill		Weft is woven over three or more warps and then under one. In the next row, the pattern is shifted over one to the left or right by one warp thread	• Very strong • Dense and compact • Different faces • Diagonal design on surface • Soft and pliable
Leno		This uses two warp threads and a single weft thread. The two adjacent warp threads cross over each other. The weft travels left to right and is woven between the two warp threads.	• Open weave • Easily distorted with wear and washing • Stretches in one direction only

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

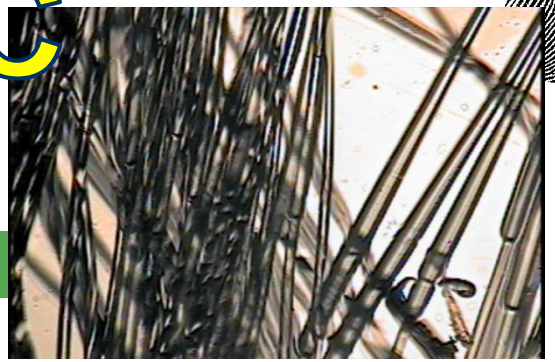
Can you identify the types of fibers shown?

A

B

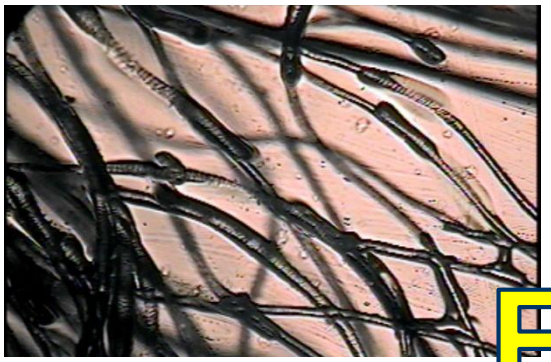


C



D

E



F

Think About It …

(1) Which samples are natural fibers?

(2) Which samples are synthetic fibers?

(3) What characteristics can be used to identify fiber samples?

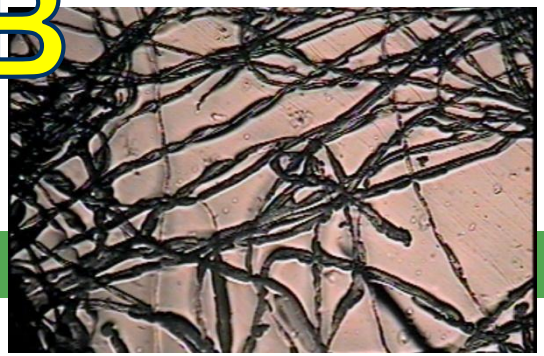
Types of Fibers - Key

A

Acrylic Yarn

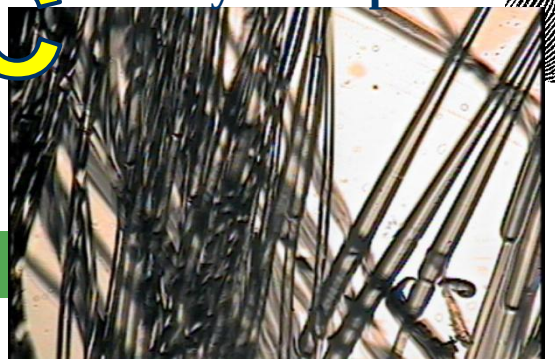
B

Cotton Yarn



C

Nylon Rope

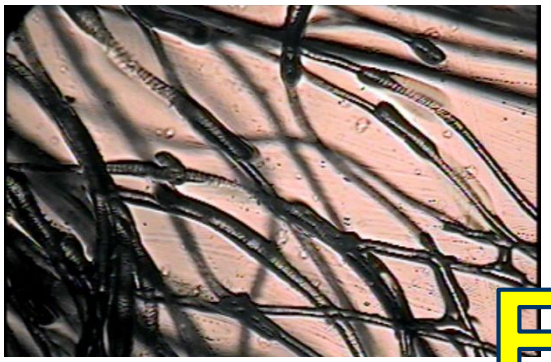


D

Polyester Yarn

E

Rayon Rope



F

Wool Yarn

Summary

- Fibers are a form of class evidence used by crime-scene investigators; they are a form of trace evidence.
- Fiber evidence may be gathered using tape, forceps, a vacuum, or a sticky lint roller.
- Forensic scientists will try to determine the type of a fiber, its color, how many fibers of each kind were found, where they were found, what textile the fiber came from, and whether there were transfers of multiple types of fibers.
- Fibers may be analyzed using polarized light microscopy, infrared spectroscopy, burn tests, or tests for solubility in different liquids.

Summary (continued)

- Fibers may be classified as natural or synthetic.
- Natural fibers include animal hair; plant fibers from seeds, fruit, stems, or leaves; and mineral fibers.
- Synthetic fibers include regenerated or modified natural fibers as well as synthetic polymer fibers.
- Fibers are spun into yarns that have specific characteristics.
- Yarns are woven, with different weave patterns, into textiles.