“Wherever he steps, whatever he touches, whatever he leaves even unconsciously, will serve as silent witness against him. Not only his fingerprints or his footprints, but his hair, the fibers from his clothes, the glass he breaks, the tool marks he leaves, the paint he scratches, the blood or semen he deposits or collects—all of these and more bear mute witness against him. This is evidence that does not forget.”

—Paul L. Kirk (1902–1970), forensic scientist
Objectives

You will understand:

Why fibers are class evidence.

How fibers can be used as circumstantial evidence to link the victim, suspect, and crime scene.

Why statistics are important in determining the value of evidence.
You will be able to:

Distinguish and identify different types of fibers.

Understand polymerization.

Carry out an experiment in thin-layer chromatography.

Judge the probative value of fiber evidence.

Design and carry out scientific investigations.

Use technology and mathematics to improve investigations and communications.
Fibers

Are considered class evidence

Have probative value

Are common trace evidence at a crime scene

Can be characterized based on comparison of both physical and chemical properties
Fabric

Fabric is made of fibers. Fibers are made of twisted filaments.

Types of fibers and fabric:
- Natural—animal, vegetable, or inorganic
- Artificial—synthesized or created from altered natural sources

Courtesy of Barbara Ball
Types of Fibers

**Synthetic**
- Rayon
- Nylon
- Acetate
- Acrylic
- Spandex
- Polyester

**Natural**
- Silk
- Cotton
- Wool
- Mohair
- Cashmere

Courtesy of Barbara Ball
Classification

Natural fibers are classified according to their origin:

- Vegetable or cellulose
- Animal or protein
- Mineral
Cellulose Fibers

**Cotton**—vegetable fiber; strong, tough, flexible, moisture-absorbent, not shape-retentive

**Rayon**—chemically altered cellulose; soft, lustrous, versatile

**Cellulose acetate**—cellulose that is chemically altered to create an entirely new compound not found in nature
Fiber Comparison

Can you describe the difference(s) between the cotton on the left and the rayon on the right?

Courtesy of Barbara Ball

Courtesy of Barbara Ball
Protein Fibers

**Wool**—animal fiber coming most often from sheep, but may be goat (mohair), rabbit (angora), camel, alpaca, llama, or vicuña.

**Silk**—insect fiber that is spun by a silkworm to make its cocoon; the fiber reflects light and has insulating properties.
Mineral Fibers

**Asbestos**—a natural fiber that has been used in fire-resistant substances

**Rock wool**—a manufactured mineral fiber

**Fiberglass**—a manufactured inorganic fiber

Fiberglass

bonzodog/Shutterstock.com
**Synthetic Fibers**

*Made from derivatives of petroleum, coal, and natural gas*

**Nylon**—most durable of man-made fibers; extremely lightweight

**Polyester**—most widely used man-made fiber

**Acrylic**—provides warmth from a lightweight, soft, and resilient fiber

**Spandex**—extreme elastic properties
Fabric Production

Fabrics are composed of individual threads or yarns that are made of fibers and are knitted, woven, bonded, crocheted, felted, knotted, or laminated. Most are either woven or knitted. The degree of stretch, absorbency, water repellence, softness, and durability are all individual qualities of the different fabrics.

Courtesy of Barbara Ball
Weave Terminology

**Yarn**—a continuous strand of fibers or filaments that may be twisted together

**Warp**—lengthwise yarn

**Weft**—crosswise yarn

**Blend**—a fabric made up of two or more different types of fibers

Courtesy of Barbara Ball
Weave Patterns

Plain

Satin

twill

Courtesy of Barbara Ball
Plain Weave

The simplest and most common weave pattern

The warp and weft yarns pass under each other alternately

Design resembles a checkerboard

Courtesy of Barbara Ball
Twill Weave

The warp yarn is passed over one to three weft yarns before going under one.

Makes a diagonal weave pattern.

Design resembles stair steps.

Denim is one of the most common examples.
Satin Weave

The yarn interlacing is not uniform
Creates long floats
Interlacing weave passes over four or more yarns
Satin is the most obvious example
Knitted Fabric

Knitted fabrics are made by interlocking loops into a specific arrangement. It may be one continuous thread or a combination. Either way, the yarn is formed into successive rows of loops and then drawn through another series of loops to make the fabric.

Courtesy of Barbara Ball
Polymers

Synthetic fibers are made of polymers, which are long chains of repeating chemical units.

The word *polymer* means many (*poly*) units (*mer*).

The repeating units of a polymer are called monomers.

By varying the chemical structure of the monomers or by varying the way they are joined together, polymers are created that have different properties.

As a result of these differences, they can be distinguished from one another forensically.
Synthetic fibers are forced out of a nozzle when they are hot, and then they are woven. The holes of the nozzle are not necessarily round; therefore, the fiber filament may have a unique shape in cross section.
Testing for Identification

Microscopic observation

**Burning**—observation of how a fiber burns, the odor, color of flame, color of smoke, and the appearance of the residue

**Thermal decomposition**—gently heating to break down the fiber to the basic monomers

**Chemical tests**—solubility and decomposition

Courtesy of Barbara Ball
Testing for Identification

**Density**—the mass of an object divided by the volume of the object

**Refractive index**—measurement of the bending of light as it passes from air into a solid or liquid

**Fluorescence**—absorption and reemission of light; used for comparing fibers as well as spotting fibers for collection
Components that make up dyes can be separated and matched to an unknown.

There are more than 7,000 different dye formulations.

Chromatography is used to separate dyes for comparative analysis.

The way a fabric accepts a particular dye may also be used to identify and compare samples.

Courtesy of Barbara Ball
Collection of Fiber Evidence

Bag clothing items individually in paper bags. Make sure that different items are not placed on the same surface before being bagged.

Make tape lifts of exposed skin areas and any inanimate objects.

Removed fibers should be folded into a small sheet of paper and stored in a paper bag.

Courtesy of Barbara Ball
Fiber Evidence

Fiber evidence in court cases can be used to connect the suspect to the victim or to the crime scene. In the case of Wayne Williams, fibers weighed heavily on the outcome of the case. Williams was convicted in 1982 based on carpet fibers that were found in his home, in his car, and on several murder victims.