
The Study of Hair

Learning Objectives

- I can describe the structure of hair
- I can differentiate between types of hair
- I can explain hairs use in a forensic investigation

Hair as Evidence

Hair is considered class evidence without the follicle

Hair is left behind as trace evidence at a crime scene and on clothes, carpets and other locations

Hair provides a record of drugs, toxins, heavy metals, and nutritional deficiencies

Hair follicles can contain DNA and is classified as individual evidence

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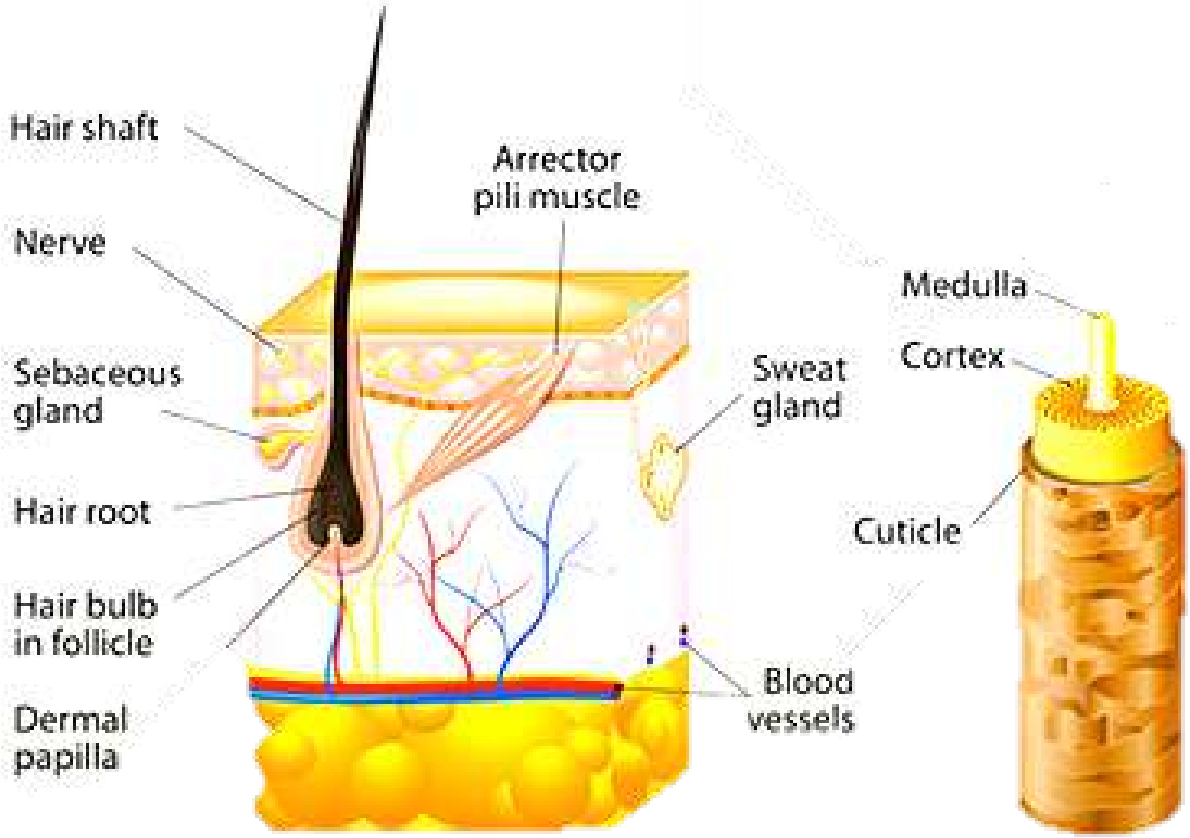
Function and Structure of Hair

Hair on mammals helps to regulate body temperature, decrease friction, and protect against sunlight.



Life Cycle of the Hair

Hair proceeds through 3 stages as it develops:

1. During the long **anagen** stage, hair actively grows. The cells around the follicle rapidly divide and deposit materials in the hair.
2. In the **catagen** stage, the hair grows and changes.
3. Hair is in the **telogen** stage when the follicle becomes dormant. During this stage, hairs easily can be lost.

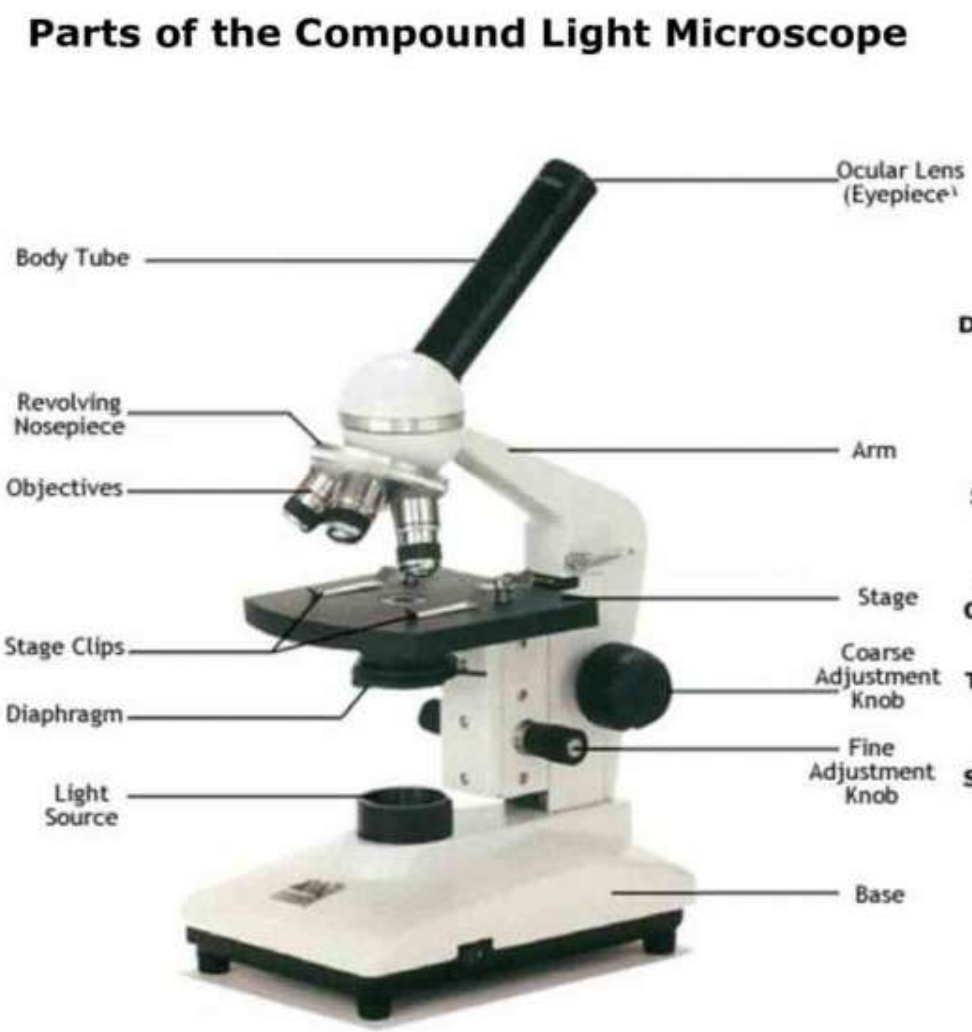
Hair in Investigations

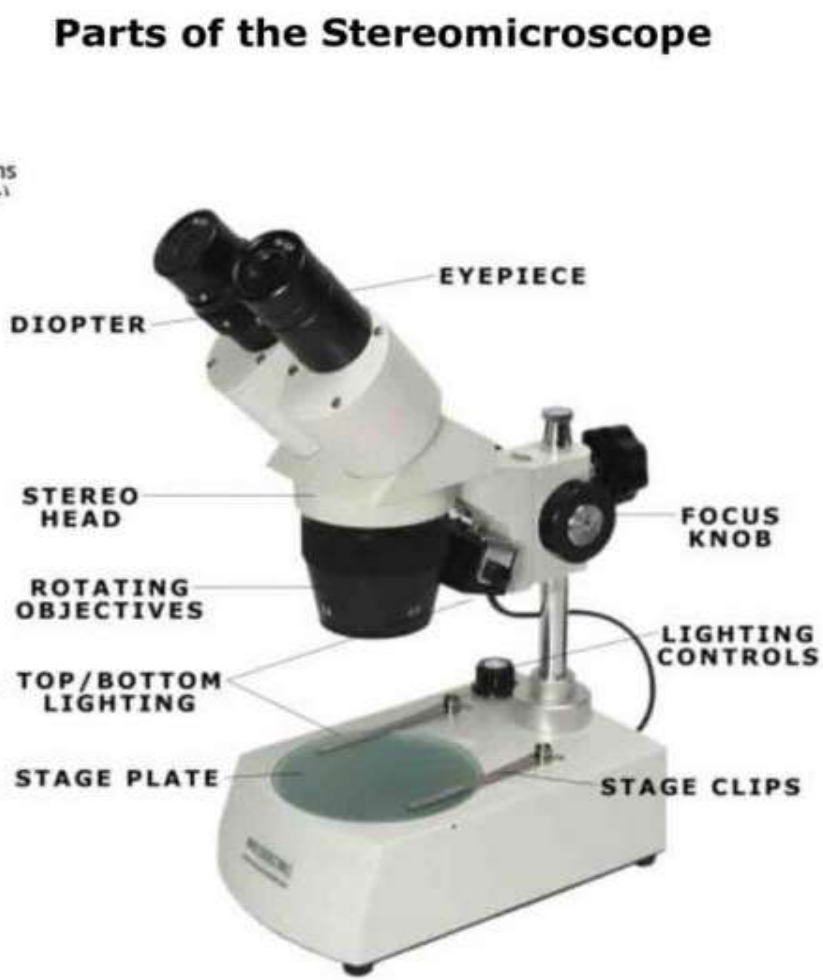
Hair is a major source of trace evidence left behind at crime scenes.

Hair can be collected by hand, gathered using tape, or vacuumed from a large surface.

Once collected hairs will be examined on the macroscopic level to determine length, color, texture, and species

Microscopy


Parts of the Compound Light Microscope
Ocular Lens (Eyepiece)
Body Tube
Revolving Nosepiece
Arm
Objectives
Stage
Stage Clips
Coarse Adjustment Knob
Diaphragm
Fine Adjustment Knob
Light Source
Base


Parts of the Stereomicroscope
EYEPIECE
DIOPTER
STEREO HEAD
FOCUS KNOB
ROTATING OBJECTIVES
LIGHTING CONTROLS
TOP/BOTTOM LIGHTING
STAGE PLATE
STAGE CLIPS

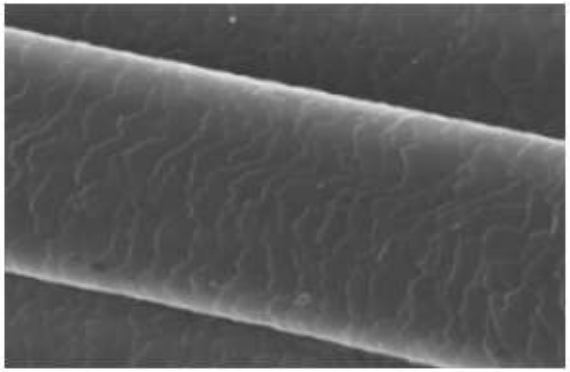
Microscopy

Hair is typically magnified from 40-400x to observe microscopic characteristics: scales on the cuticle, medullary pattern, pigmentation of the cortex.

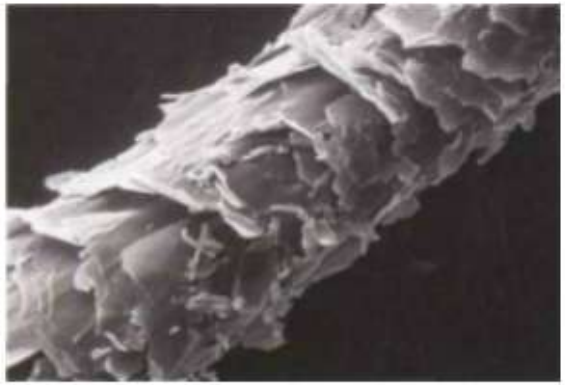
The Cuticle

The cuticle is a translucent outer layer of the hair shaft consisting of scales that cover the shaft.

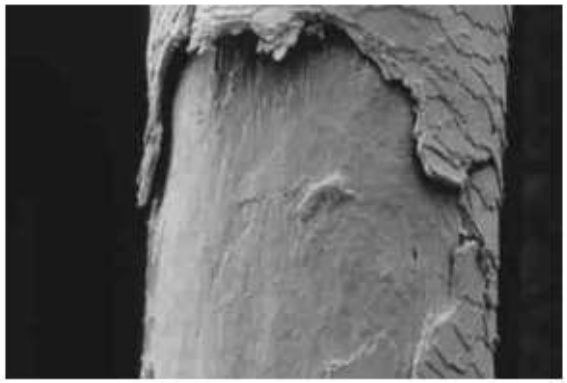
Cuticular scales always point from the proximal or root end of the hair to the distal or tip end of the hair.



Healthy Cuticle Layer



Raised Cuticle Layer



Damaged Cuticle Layer Missing Scales

The Cuticle

The cuticle scales of animals commonly resemble petals (spinous) or a stack of crowns (coronal).

The cuticle scales of humans commonly are flattened and narrow (imbricate).

The Cortex

The **Cortex** contains most of the pigment granules that give hair its color.

In animals pigmentation is denser toward the medulla and can change abruptly in banded patterns down the shaft.

In humans pigmentation is denser toward the cuticle and any change in color indicates treated hair.

Treated Hair

Forensic investigators sometimes can link hair from a location with an individual.

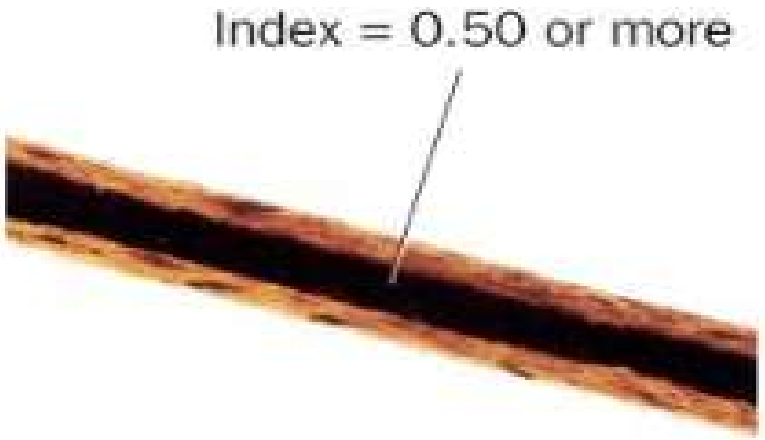
- **Bleaching** disturbs the scales on the cuticle and removes pigment leaving hair brittle and a yellowish color.
- **Dyeing** colors the cuticle and the cortex of the hair shaft.

Forensic scientists can estimate when hair was last treated given a standard growth rate of 1.3 cm per month.

The Medulla

The thickness of the medulla, or medullary index, can be used to determine if the hair is human.

$$\text{Medullary Index} = \frac{\text{medulla's width}}{\text{entire hair's width}}$$



Cattle hair

Human hair

The Medulla

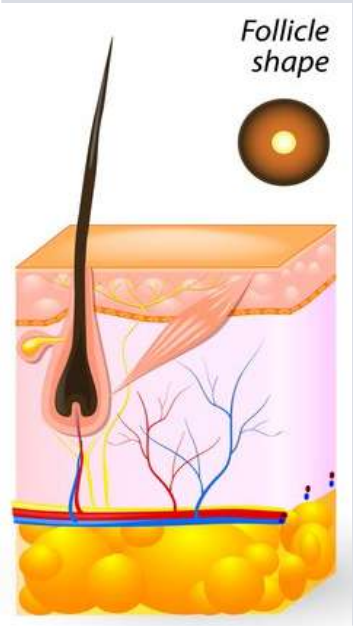
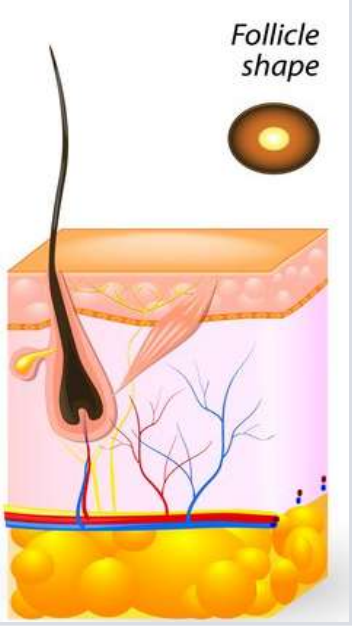
The medulla can be hollow or filled, absent, fragmented, continuous, doubled, pigmented, or un- pigmented.

Medullary pattern can help to identify what species the hair is from

Medulla Pattern	Description	Diagram
Continuous	One unbroken line of color	
Interrupted (intermittent)	Pigmented line broken at regular intervals	
Fragmented or Segmented	Pigmented line unevenly spaced	
Solid	Pigmented area filling both the medulla and the cortex	
None	No separate pigmentation in the medulla	

Racial Differences

Hair examiners have identified certain characteristics to generally be associated with broad racial groups, though they don't fit each individual.

Asian	Caucasian	African
		
Generally straight hair	Generally wavy to straight hair	Generally curly to coiled hair
Round cross section with a large diameter	Oval or round cross section with a moderate diameter	Flattened cross section and with moderate to small diameter

Testing for Substances

Arsenic, lead, and the presence of many drugs can be detected by chemical analysis of the hair.

A time line of exposure can also be determined given the standard growth rate of 1.3 cm per month.

Neutron activation analysis (NAA) is used to identify the concentration of multiple elements in a strand of hair. The probability of the hairs of two individuals having the same concentration of nine elements is one in one million.

Testing the Hair Follicle

If hair is pulled out by the root it may leave behind a follicular tag. If this occurs blood and tissue attached to the follicle may be analyzed for DNA evidence.

Study of Fibers and Textiles

Learning Objectives

- I can describe weave patterns of various textiles
- I can use forensic science to identify and describe common natural and synthetic fibers

Fibers and Textiles as Evidence

Fibers can be identified by type and composition, determined by microscopes, gas chromatography, and mass spectrometers

Textiles can be identified by weave pattern, thread count, or two ply fabric layering

Fiber identification provides class evidence only and should not be used to convict someone.

Collecting fibers within 24 hours is critical.

Sampling and Testing

Shedding from an article of clothing or a textile is the most common form of fiber transfer.

Natural fibers can be viewed with an ordinary microscope with or without a polarizer.

Synthetic fibers may require infrared spectroscopy can reveal chemical makeup since their physical structure is indistinct.

If a large quantity of fibers is found, some can be subjected to destructive tests such as burning them in a flame (see analysis key above) or dissolving them in various liquids.

Comparison of Fibers - Cotton

Natural plant fiber with a flattened hose appearance

Composed of chains of glucose forming cellulose polymers

Up to 2 inches long, tapers to a blunt point and may have a frayed root

Smells like burnt hair when burned

Used in many types of textiles for clothing

Comparison of Fibers - Flax

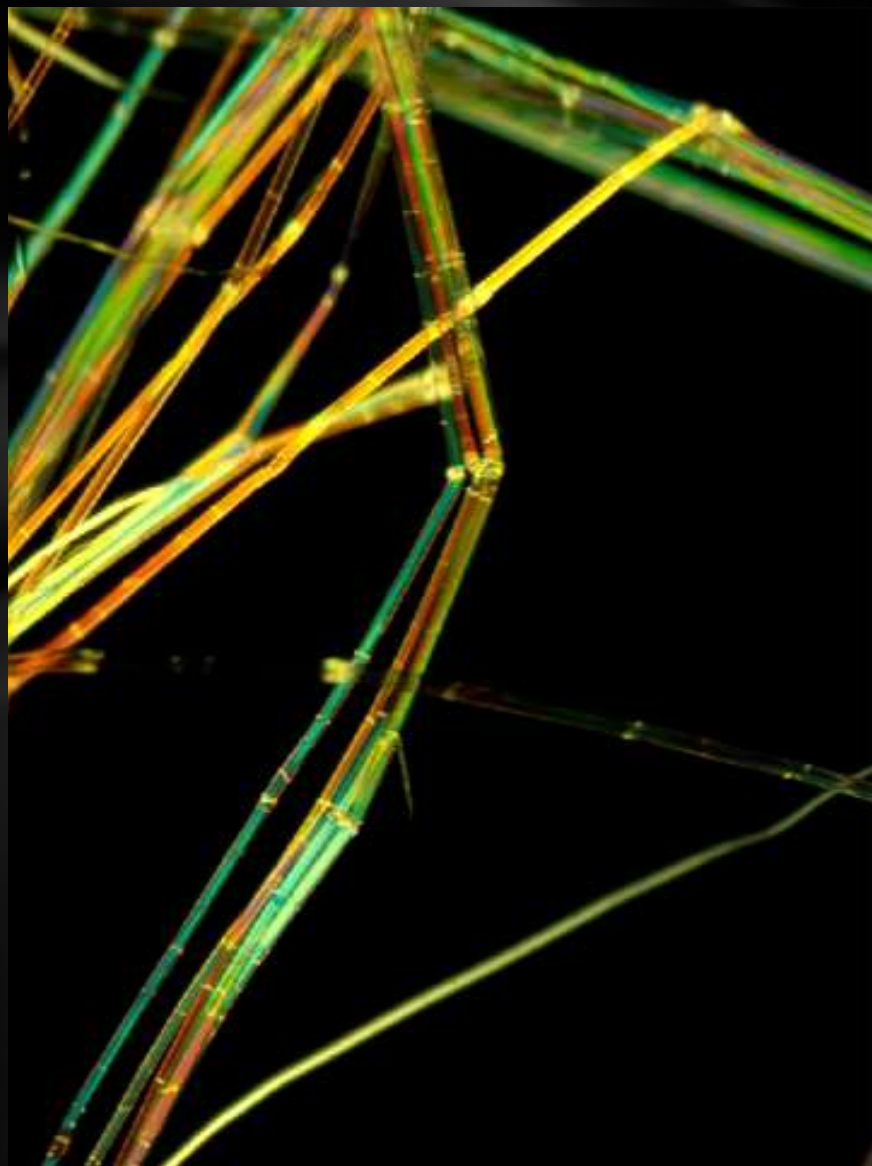
Natural plant fiber with a bamboo appearance

Composed of chains of glucose forming cellulose polymers

Crystalline structure with nodes visible in an “X” every inch or so

Often occur bundled with several fibers

Used in bed linens and table cloths



Comparison of Fibers - Silk

Natural animal fiber from the cocoon of caterpillars

Composed of a protein which scatters light similar to a prism and gives glossy appearance

Fibers do not taper but may have small variations in diameter

No internal structure

Used in clothing and bedding

Comparison of Fibers - Wool

Natural animal fiber from sheep hair

Composed of a protein chain called keratin

Surface scales may be visible

Hollow or partially hollow core

Fibers up to 3 inches long tapering to a fine point

Used in clothing and blankets

Comparison of Fibers - Synthetic

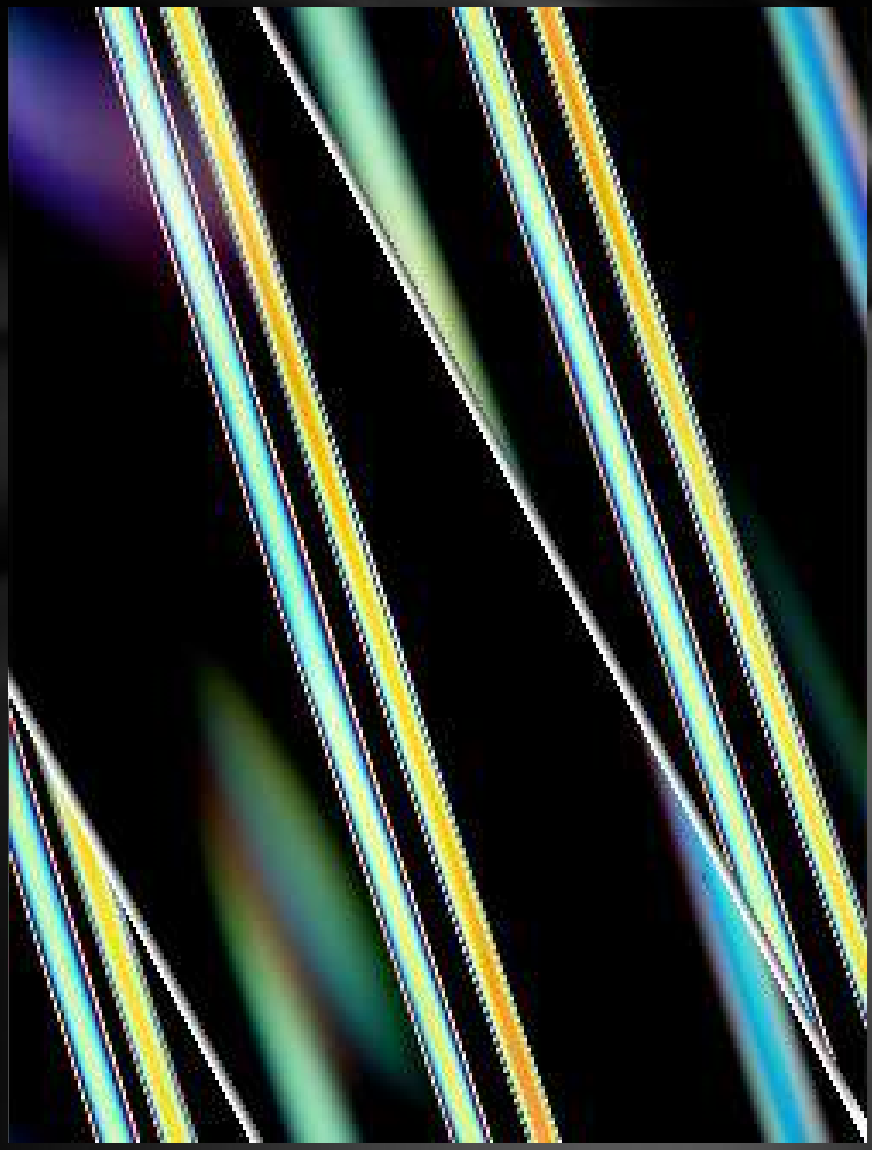
Include rayon, nylon, acrylics, and polyester

Some made with cellulose, others made with petroleum

Uniform diameter throughout the fiber

Surface treatments appear as spots or stains

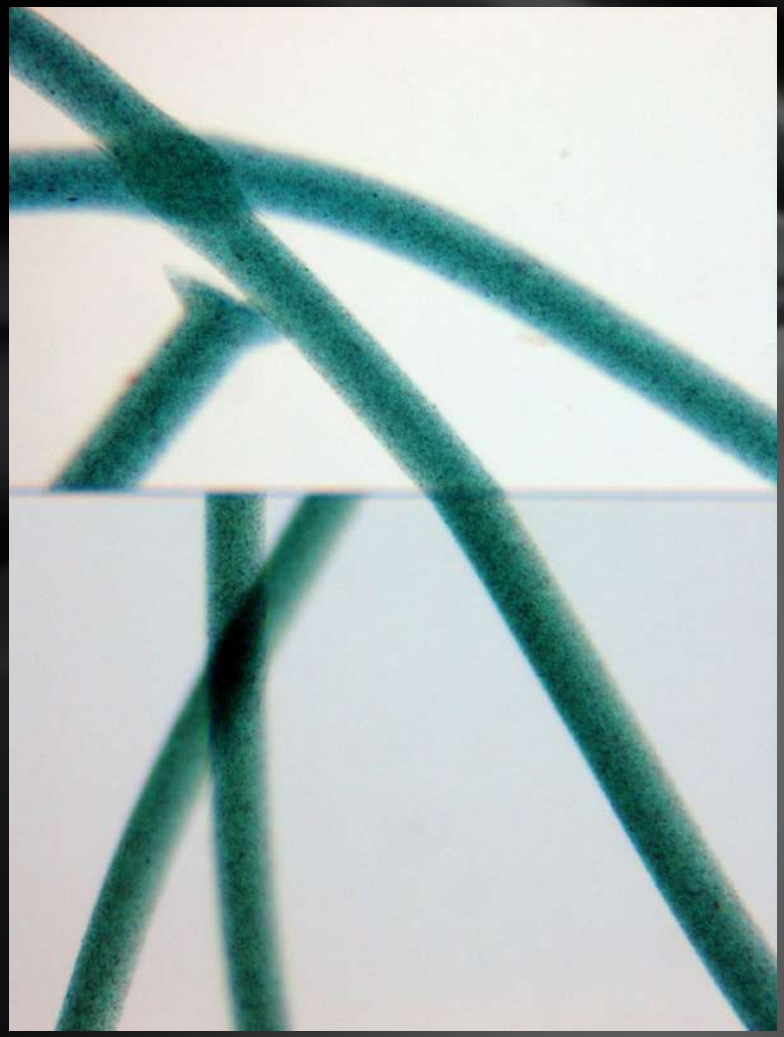
Used in clothing, bedding, towels, carpets



Fiber Analysis: Step 1

Fibers should be first examined using stereomicroscopy.

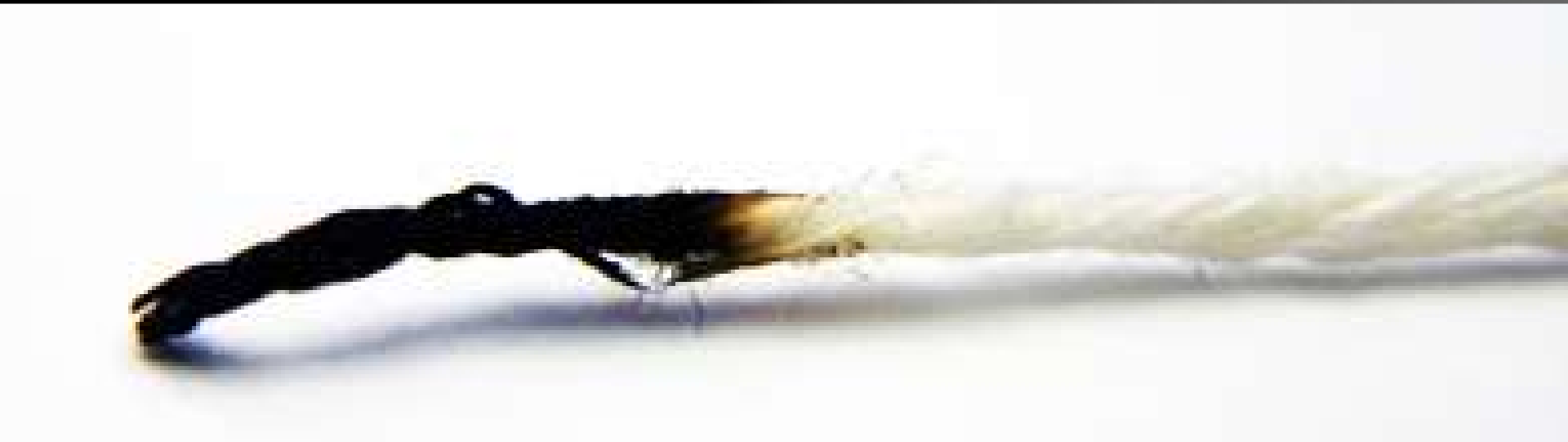
- Physical features length, color, diameter, luster, cross section, damage, and debris should be noted
- Similar fibers may be compared further using a comparison microscope



Fiber Analysis: Step 2

If enough fibers are found some may be burned to aid in identification

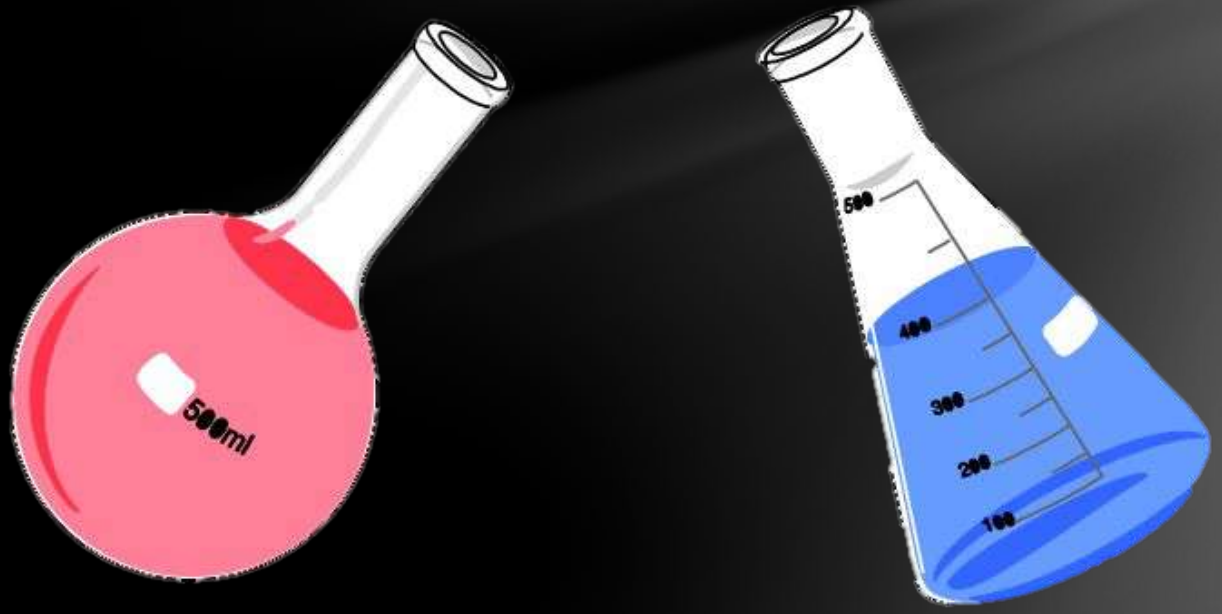
- Odor of burning hair – Animal source
- Odor of burning paper – Plant source
- Melts, but does not burn – Synthetic



Fiber Analysis: Step 3

Fibers may also be chemically treated to narrow down the source

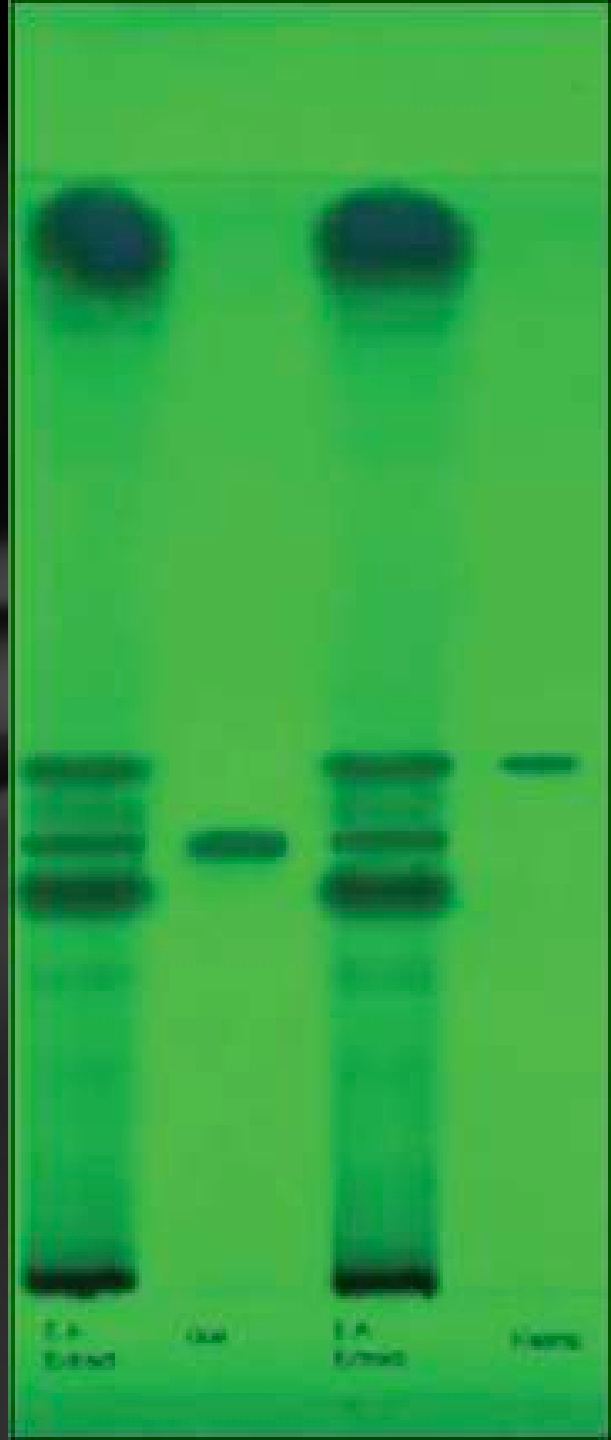
- Dissolves in strong acid – plant, silk, or manufactured.
- Dissolves in strong base – wool



Fiber Analysis: Step 4

Analysis of dyes can be done.

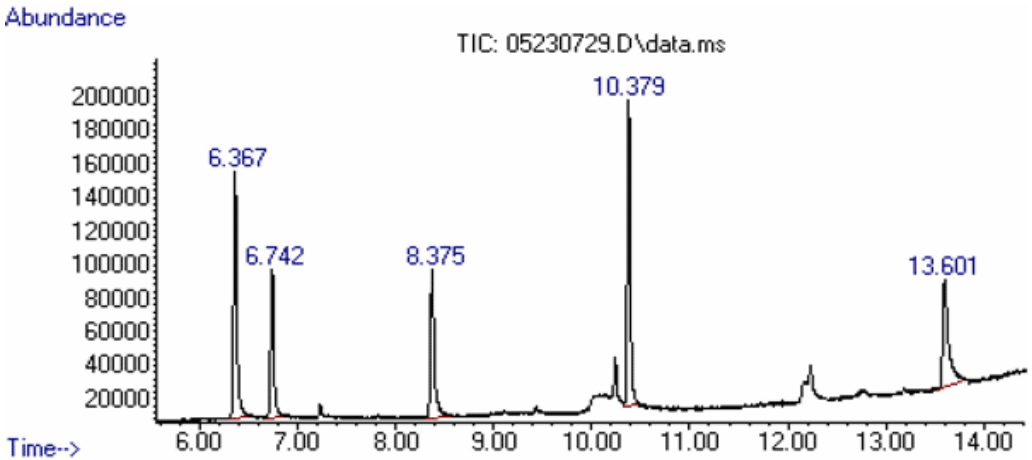
- Using Microspectrophotometry (MSP) light absorbed by or reflected from a sample is separated into its component wavelengths, and intensity at each wavelength plotted.
- Using Thin-layer chromatography (TLC) Dye components are separated by their migration pattern as the dye flows through a medium.



Fiber Analysis: Step 5

The chemical makeup of the fiber itself can be analyzed through further testing

- The Gas chromatography (GCMS) instrument is made up of two parts. The gas chromatography (GC) portion separates the chemical mixture into pulses of pure chemicals and the mass spectrometer (MS) identifies and quantifies the chemicals.



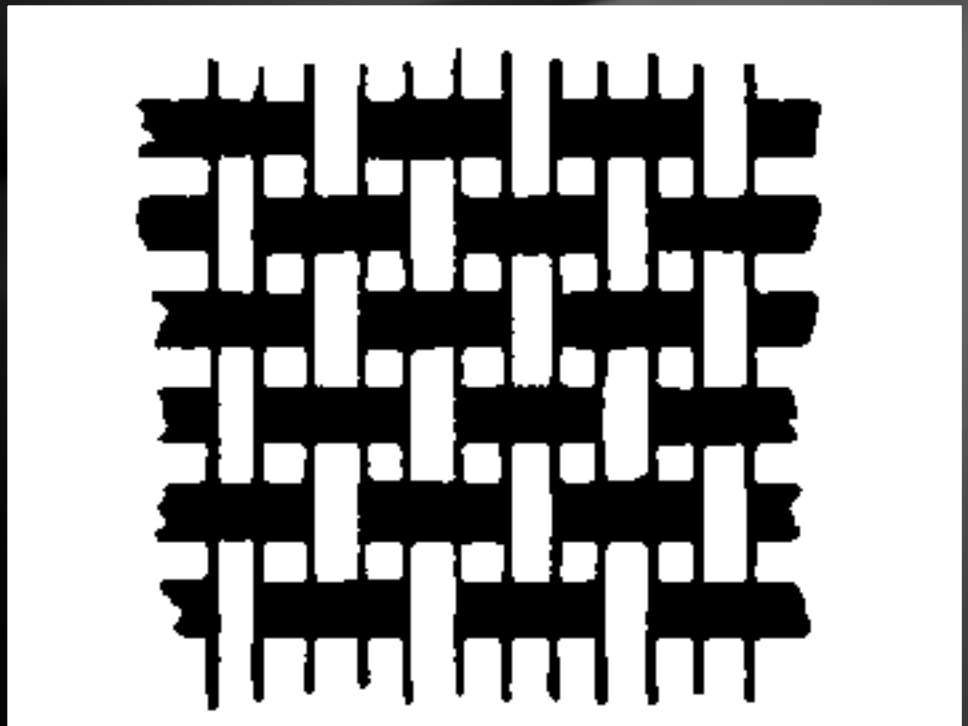
Weave Patterns - Plain

Alternating warp and weft

Firm and wears well

Low tear strength

Tends to wrinkle



Weave Patterns - Basket

Alternating pattern of two weft threads crossing two warp threads

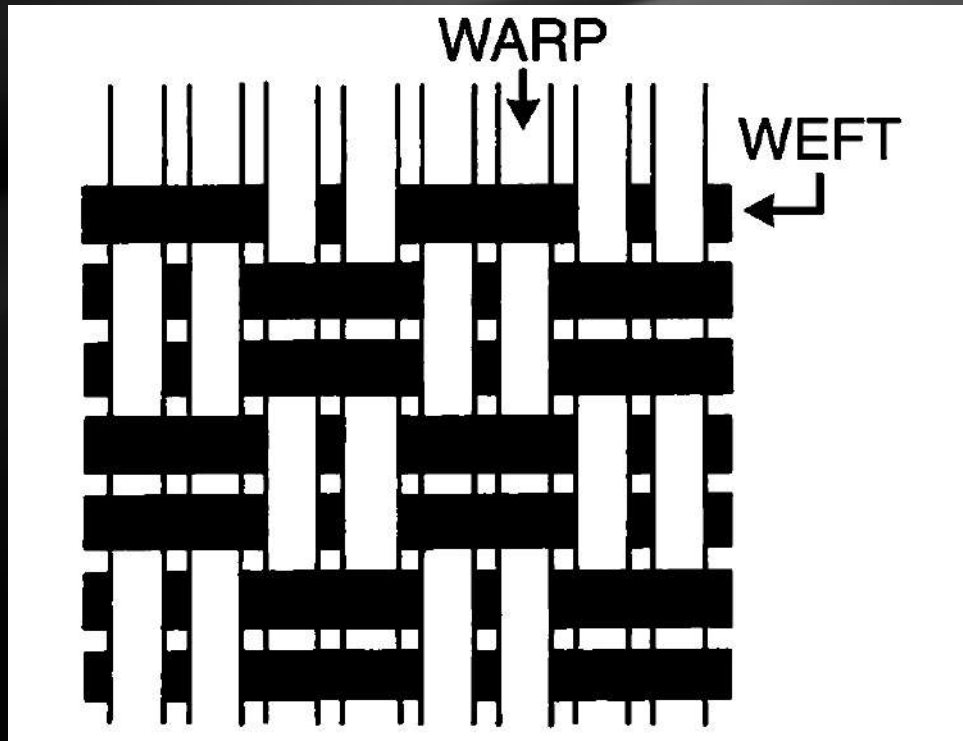
An open or porous weave

Does not wrinkle

Not very durable

Tends to distort as yarns shift

Shrinks when washed



Weave Patterns - Satin

A weft crosses over three or more warp threads

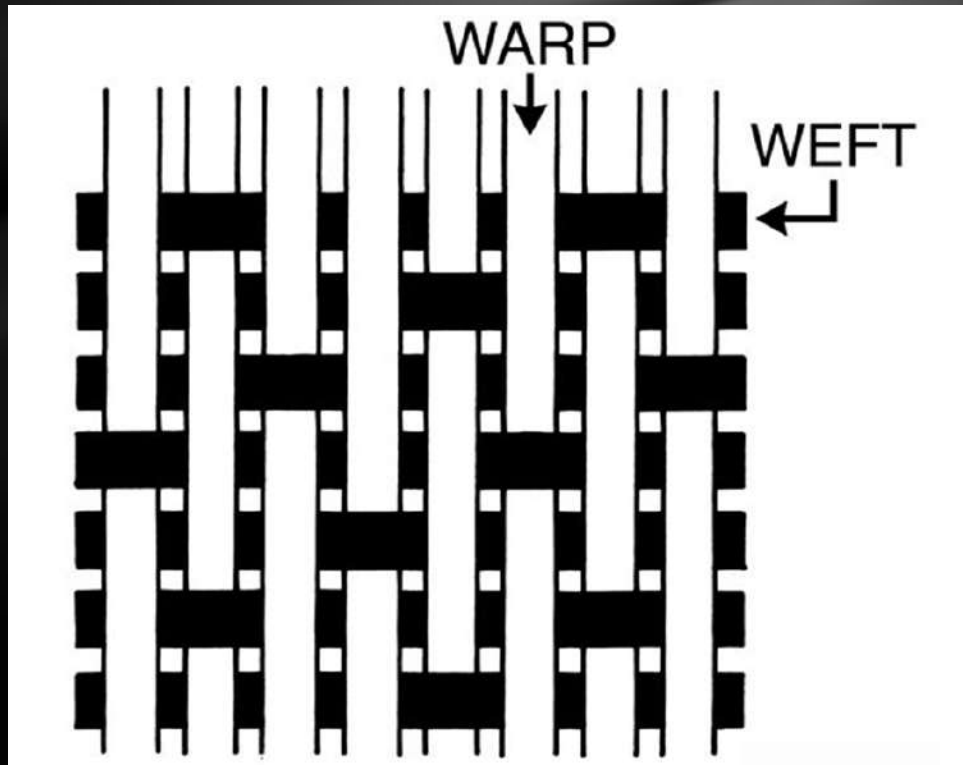
Not durable

Tends to snag and break during wear

Shiny surface

High light reflectance

Little friction with other garments



Weave Patterns - Twill

Weft is woven over three or more warps and then under one. The next row the pattern is shifted by one thread.

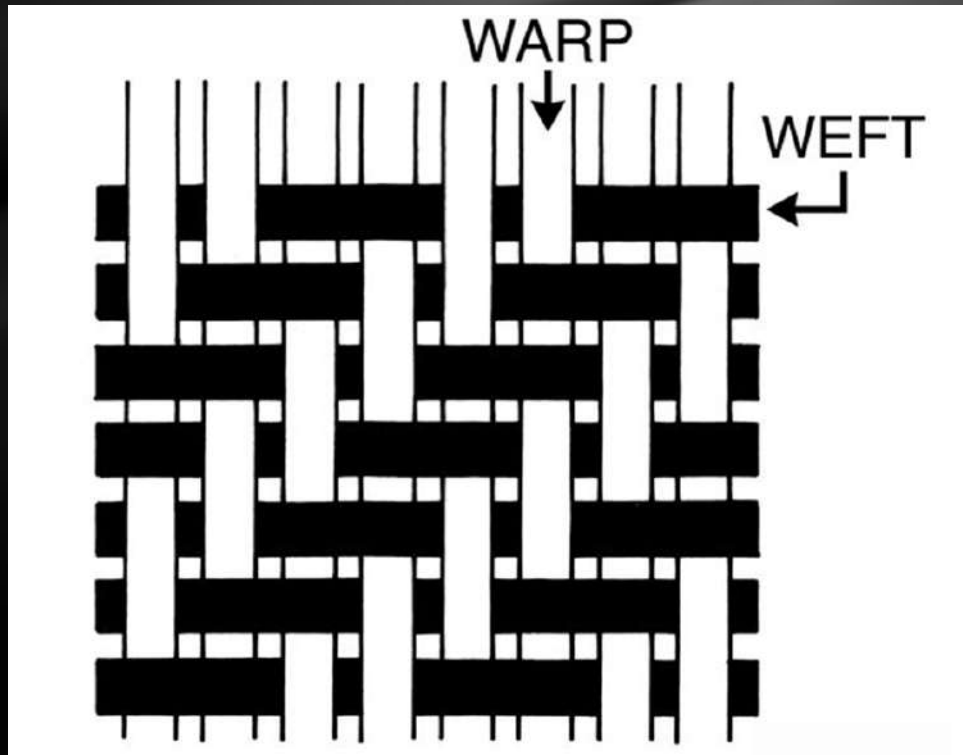
Very strong

Dense and compact

Different faces

Diagonal design on surface

Soft and pliable



Weave Patterns - Leno

This uses two warp threads and a single weft thread. The two adjacent warp threads cross over each other the weft is woven between the two warp threads

Open weave

Easily distorted with wear and washing

Stretches in one direction only