

# Forensic Science: Identification of Fibers

## Background Information

Fibers, strands of thread that make up yarn and cloth, are all around us. You encounter a wide variety of fibers every day. Fibers make up thousands of products including clothing, upholstery, carpet, rope, and building materials. According to the Locard Exchange Principle, when you enter a room, you pick up some of the fibers present in the room. You also drop some of the fibers that you are carrying. Therefore, fiber evidence can often provide information about where people have been.

In order to have fiber evidence to be of any value in a criminal investigation, forensic scientists need to narrow the origin of the fiber to one or two possible sources. This is very difficult to do because most clothing, upholstery and carpets are mass-produced. It is only under unusual and extraordinary circumstances that fiber evidence can be used to positively identify and individual.

Fibers can be divided into two large groups: natural and man-made. The earliest people wore animal skins and furs for clothing. Since the Stone Age, man has been harvesting fibers from plants and animals and weaving them into fabric for clothing. Wool, silk, cotton, flax and the husks of some types of dry fruits are examples of natural fibers. From these plant and animal products, people learned to form individual threads that could be woven into large pieces of cloth. By the time of the industrial revolution, weaving was a mechanized process that produced plenty of fabric for the growing population. However, the fabric industry still depended upon nature for its raw materials. Drought, flooding, disease, and cold weather could badly damage the fiber crops and reduce the amount of cloth available.

After the industrial revolution, scientists began searching for a fiber that could be made in the laboratory. Such a discovery would provide manufacturers with a constant supply of fibers. In 1910, the first man-made fiber was created in a laboratory and named "Rayon". Rayon was not a true synthetic fiber because it utilized natural cellulose in the form of wood in its production. Rayon was made by chopping and chemically treating wood pulp and cotton to produce a soft

mass of cellulose. This cellulose was then forced through tiny openings in a device known as a spinneret to form threads. Rayon is said to be a man-made *regenerated* fiber.

Up until the 1970's, more natural than synthetic fibers were used in manufacturing; today, about twice as many synthetic fibers than natural fibers are used. Many types of man-made and synthetic fibers have been invented since the appearance of Rayon. Man-made fibers are generally classified into two groups, depending on whether or not they are derived from cellulose.

As previously mentioned, fibers derived from cellulose including rayon, acetate, triacetate and Lyocell are known as regenerated man-made fibers. Man-made synthetic fibers are fibers not derived from cellulose and include nylon, polyester, acrylic and spandex. Nylon was the first synthetic fiber ever produced and was invented by Dr. Wallace Carothers of DuPont in 1939. Nylon is the second most used synthetic fiber behind polyesters.

Most synthetic fibers are created by “extrusion” - melting the polymer chips and then forcing the thick, viscous liquid (about the consistency of cold honey) through the tiny holes of a device called a spinnerets (also spelled “spinneret”) to form continuous filaments of semi-solid polymer. The spinnerettes used in the production of most manufactured fibers look very much like a bathroom showerhead. A spinnerette may have from one to several hundred holes. As the filaments emerge from the holes in the spinnerette, the liquid polymer is converted first to a rubbery state and then solidified. This process of extrusion and solidification of endless filaments is called spinning, not to be confused with the textile operation of the same name, where short pieces of staple fiber are twisted into yarn. The fibers in conventionally spun staple yarns must be held together by twisting them together into an endless yarn bundle.

Once exposed to air-cooling, the fiber strands harden to a single filament (much like fishing line). The fibers can then be extruded into different cross-sectional shapes such as round, trilobal, hollow, and others. Why different fiber shapes? As an example, the nylon fibers used in carpet were round, which created a lens effect and magnified soil caught in the fabric. Chalk or pigments can be added into the fiber in a process called delustering. This process reduced the magnification of soil in the carpet, but the colors of the carpet were found to be dulled. Trilobal fibers were then developed. The irregular shape of trilobal-shaped fibers was found to reduce the magnification effect and scatter more light to make soil less visible while at the same time not dulling colors. Hollow fibers also provide better soil hiding with the added benefit of providing thermal insulation qualities.

The hardened fiber strands are then wound around a bobbin, stretched to a smaller diameter, twisted, and wound. While extruded fibers are solidifying, or in some cases even after they have hardened, the filaments may be drawn to impart strength. Drawing pulls the molecular chains together and orients them along the fiber axis, creating a considerably stronger yarn.

## **Identification of Fibers**

As previously discussed, a textile fiber is the basic unit or building block of a fabric. By casual observation with the naked eye, most fibers appear very similar. All fibers have a high length to width ratio (typically 100 times longer than wide). In addition, most fibers are composed of polymers. A polymer is a very large molecule that contains many repeating units of atomic structure. Different types of fibers differ widely in their physical and chemical properties.

### **Microscopic Appearance**

When viewed microscopically, some fibers exhibit longitudinal striations or cross markings while others appear smooth. Fibers may be ribbon-like or rod shaped. Many man-made fibers are naturally very lustrous (shiny). Consumers tend to prefer fabrics that are not shiny so manufacturers tend to add delustering agents or pigments to fibers. The delustering agents cause the fibers to appear speckled when viewed under a microscope.

### **Burning Characteristics**

The reactions of different fibers to a flame are varied. When brought slowly towards a flame, some fibers melt, while others tend to shrink or curl away. Once in a flame, the fiber may burn quickly, slowly, or not at all. Burning fibers may continue to burn or be self-extinguishing when removed from a flame. Many burning fibers give off a distinctive odor. The residue left from burnt fibers may be ash-like, brittle, or a hard bead.

### **Solubility**

Different fiber types react differently to various solvents. Some fibers are completely dissolved by certain solvents. Some solvents may cause structural damage to fibers or partially dissolve them.

## Staining

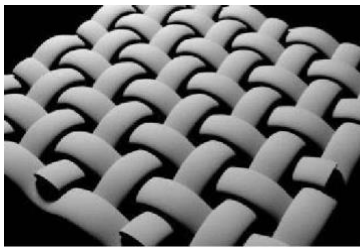
How a particular fiber reacts to different types of stains can be used to identify the fiber. The different chemical nature of fibers can cause different fibers to react very differently to the same stain. These differences can be used to help distinguish between different fiber types.

## Construction

Fabrics can be woven, knitted, or pressed from thread. The common constructions are demonstrated

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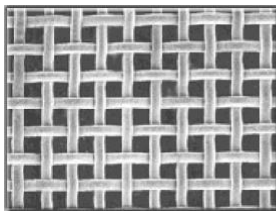
### Plain Weave, Tight



Plain weave patterns have each thread going over then under (then over then under then over then under...) each crossing thread. A "tight" pattern means that parallel threads are tight to each other (no space between them).

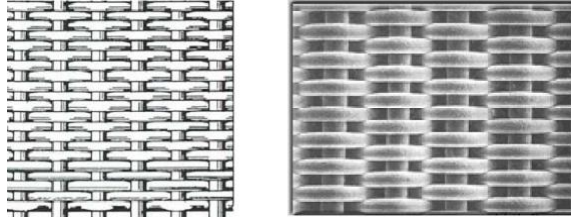
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### Plain Weave, Loose



A loose plain weave pattern has the same over under pattern as the tight plain weave pattern but there is space between the parallel. As a general rule of thumb, if the space between the threads is at least as large as the width of the thread then it is considered a loose pattern.

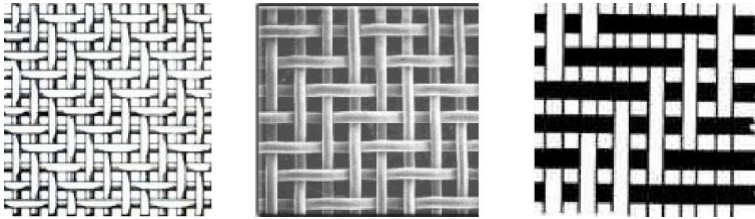
Dutch Weave



In a Dutch weave, the threads in one direction are straight and the crossing threads go over and then under (and then over and then under and then over and then under...)

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Twill



*2 x 2 Twill*

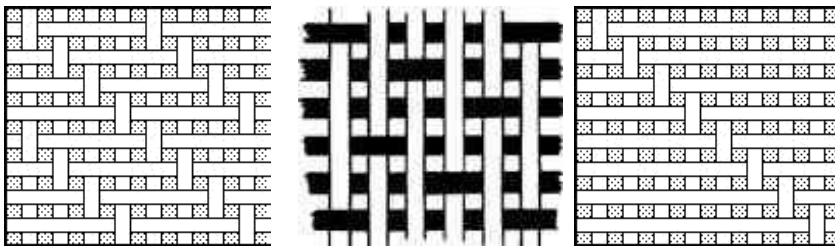
*2 x 2 Twill*

*3 x 3 Twill*

A Twill Weave is similar to a plain weave except that the threads go over and under multiple threads rather than every thread. A "2 x 2" twill jumps 2 threads at a time while a "3 x 3" twill jumps 3 threads at a time. Fabrics where threads jump more than 3 threads are classified as Satin.

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Satin



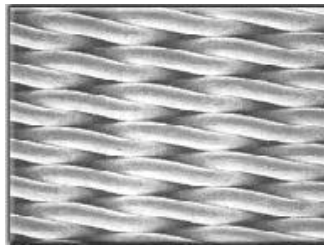
*4-harness Satin*

*5-harness Satin*

*8-harness Satin*

Similar to Twills, the threads in Satins jump more than 3 threads at a time. The number of threads being jumped is referred to as the "harness."

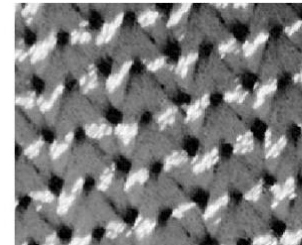
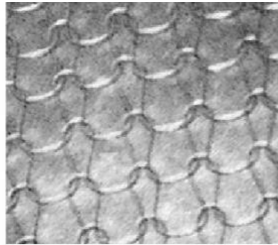
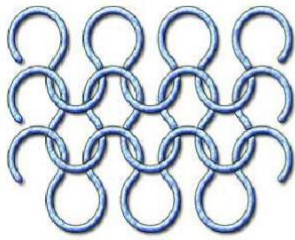
Running Weave



The primary characteristic of a Running Weave is the sideways / twisting slant of the weave.

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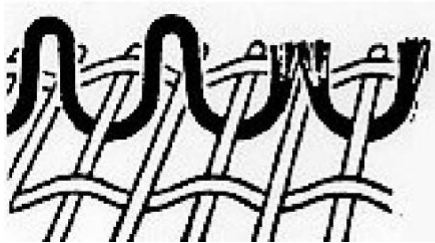
Knit



Knit is a loop passing through a loop pattern. Unlike a weave where one set of threads crosses a second set of threads, a single thread is looped over and over.

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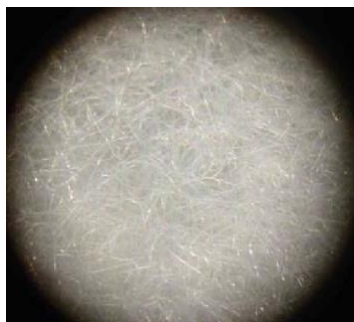
Pile



Pile refers more to the third thread used to make a thick fabric. The third thread is looped up and down through a plain weave.

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Non-Woven



Fibers in non-woven fabrics are randomly placed on each other and the fabric is then pressed. There is no discernable pattern.

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Name \_\_\_\_\_

## Pre-Lab Questions

Using the information provided in class and in the discussion above, answer the following questions in the spaces provided on your data sheet.

1. List five products that are made from fibers.
2. Why is it so difficult to trace a fiber to a particular source?
3. What are the two major classification groups of fibers?
4. What are the five examples of natural fibers?
5. What was a major drawback of depending only on natural fibers?
6. What was the first man-made fiber? How is it made?
7. List four man-made cellulosic fibers.
8. List four man-made fibers not derived from cellulose.
9. What is the name of the first synthetic fiber? Who invented it?
10. Describe the process of extrusion.
11. What is the delustering process? What happens to the colors with this process?

12. How can fibers be made less shiny without dulling their color?

13. What are the added benefits of hollow fibers?

14. What is meant by the statement “fibers have a high length to width ratio”?

15. Define what a polymer is.

16. Consumers tend to prefer fabrics that are not shiny, so what do manufacturing companies do to the fibers to prevent this?

17. When brought slowly to a flame, what are some of the ways fibers behave?

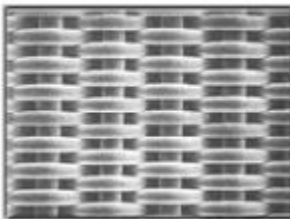
18. Once in a flame, what are some ways fibers can behave?

19. The residue left from burnt fibers may be \_\_\_\_\_, \_\_\_\_\_ or \_\_\_\_\_.

20. Some fibers are \_\_\_\_\_ dissolved by certain solvents, some solvents may cause \_\_\_\_\_ to fibers or partially \_\_\_\_\_ them.

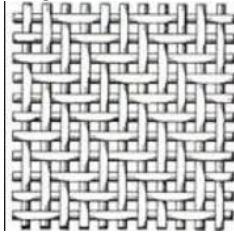
21. What kind of weave are the following?

a)



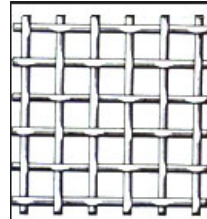
\_\_\_\_\_

b)



\_\_\_\_\_

c)



\_\_\_\_\_

22) How are non-woven fabrics/fibers formed?