Week 11: Lab#11 Forensic Trace Analysis: Hairs and Fibers

"Trace Evidence" can take many forms. Such evidence can include paint chips from vehicles; hairs and fibers; organic material such as wood, plants, or leaves; soil; and pollen, just name a few. Locard's Exchange Principle (paraphrased) says that one cannot leave a crime scene without either leaving evidence or picking up evidence. Trace evidence like hairs, fibers, and pollen are very good examples of this principle. Many times, people are unaware that such evidence has been picked up or left behind. Last week you looked at the trace evidence of plants and pollen. In this lab activity today, you will be looking at two more types of trace evidence - hairs and fibers- that can be useful evidence to assist in forming a connection to a person and/or a location.

HAIRS & FIBERS *(from Ward's Hair and Fiber Activity Handout)*

Physical Evidence

Physical evidence can be defined as "any or all objects that can establish that a crime has been committed or can provide a link between a crime and its victim or a crime and its perpetrator" (Saferstein, 2004). Examples of physical evidence include DNA, fingerprints, documents, drugs, fibers, hair, glass, and soil to name a few. When physical evidence is too small to be examined with the naked eye (i.e. microscopic), it is referred to as trace evidence. The basis for the study of trace evidence is the Locard Exchange Principle which states that whenever an individual comes in contact with another person or object, there will be at least some material either transferred to or from the site.

Class Characteristics vs. Individual Characteristics

Every piece of physical evidence is considered to be either class evidence or individual evidence. The classification depends upon the degree of certainty to which the evidence can be linked to a particular source. When evidence can only be associated with a group and not a single source, it is said to possess class characteristics. For example, hair tends to exhibit a variety of morphological characteristics from one person to another and within a single individual, thus it cannot be individualized to a single head or body through its morphology and is considered class evidence. In contrast, if there is a strong likelihood that a piece of evidence can be associated with a common source, the evidence is said to possess individual characteristics. Fingerprints are a good example of individual evidence, since no two people are known to have matching fingerprints.

Comparing Evidence

There are actually two steps to a forensic comparison. The first step is to select, and directly compare, certain properties from a questioned and a known standard or reference sample. The next step is to render a conclusion as to the origins of the compared samples. Could the specimens have originated from the same source?

To a forensic scientist, hairs and fibers are considered to be forms of trace evidence transferred either by direct (primary) contact or indirect (secondary) contact during a commission of a crime. No matter how the evidence was transferred, there is a great deal of information that can be learned from analyzing such evidence.

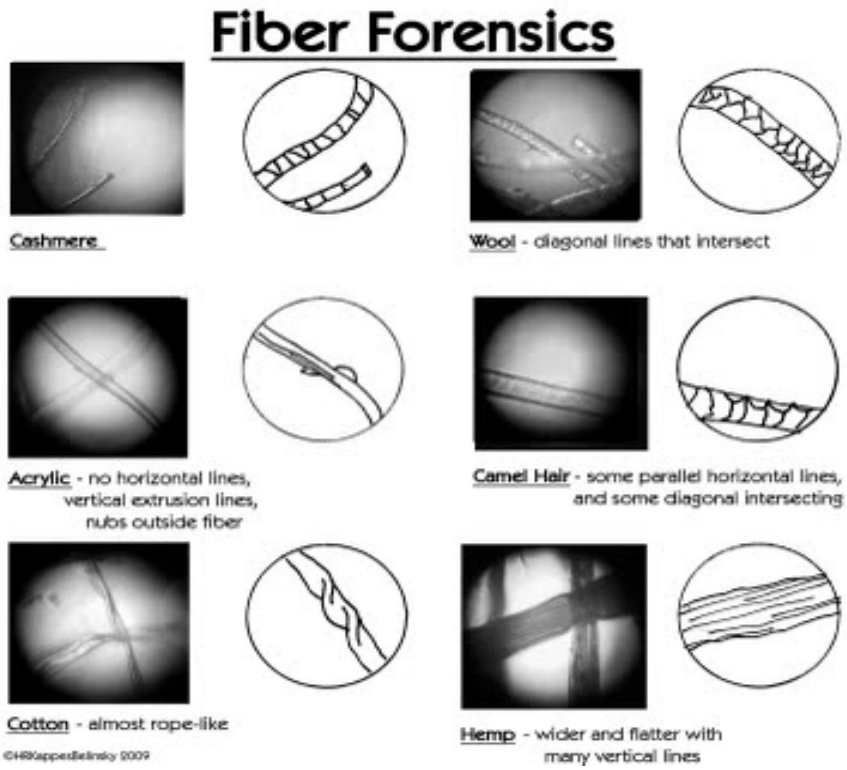
Fibers

By definition, a fiber is the smallest unit of a material that has a length many times greater than its diameter. It can be spun with other fibers to form a yarn that can then be woven or knitted to form a fabric. Fibers are classified into two main categories: natural and man- made (synthetic).

Natural fibers are derived entirely from plant or animal sources. The most commonly encountered plant-derived fibers include cotton, hemp, linen, and jute. Whereas the most frequently encountered animal-derived fibers are wool, silk, mohair, cashmere, and fur.

Synthetic fibers comprise more than half of all fibers used in the production of textile materials. The most commonly encountered man- made fibers are polyester, nylon, acrylic, rayon, and acetate. These types of fibers can be readily distinguished from animal fibers in that they have no medulla or scale pattern.

When examining fiber evidence, characteristics such as fiber type, shape, diameter, color, variation of color in the fiber, length of fiber, and lengthwise striations on the fiber's surface are noted.

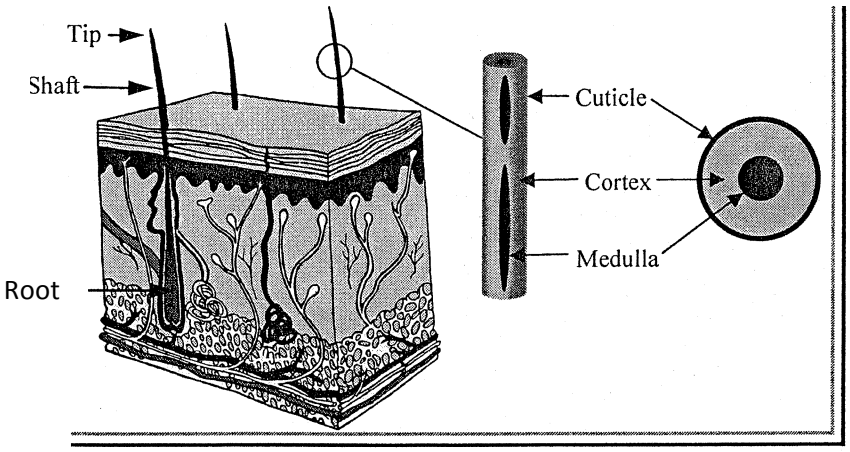


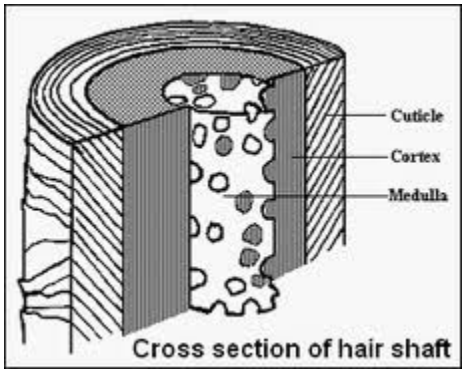
http://apenderforensics.blogspot.com/2009_09_01_archive.html

Hairs

Hair is a physical feature unique to mammals. It originates and grows from living connective tissue within a follicle. Each growing hair consists of a living root embedded in the skin and a non-living shaft projecting above the skin. The hair shaft is composed of the fibrous protein keratin and is made up of three layers: the cuticle, the cortex, and the medulla (Figure 1).

Figure 1
Hair Anatomy





http://cwennerforensics.blogspot.com/2011/11/hairfiber-analysis.html

What are the Morphological Characteristics of the Hair?

Hair is one type of "fiber" analyzed and compared as physical evidence. When attempting to link an individual to a crime, it is necessary to perform a much more exhaustive examination of the hair(s) in ques- tion. Characteristics such as color, length, diameter, medulla patterns, and medulla shape are considered to be of particular importance.

"Fall out" hair-club shaped root

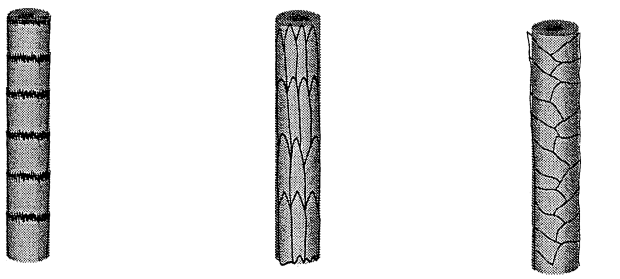
Forcibly removed hairs may have stretching, damage to root.

Hair with root tissue.

The Cuticle

The cuticle, or outermost layer, is made up of dead, translucent cells that form scales to give hair its strength. The cuticle can have one, or a combination, of three basic scale patterns that can be observed on cuticles: coronal (crown-like), spinous (petal-like), or imbricate (flattened) as shown in Figure 2. The condition of the cuticle (undamaged or damaged) will determine the level of strength, shine, and texture of the hair shaft.

Figure 2 Scale Patterns



Coronal Spinous Imbricate

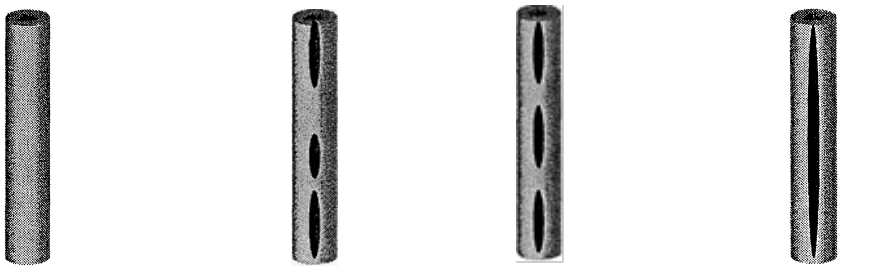
The Cortex

The color of hair is determined by the amount and type of the melanin pigment contained within the cortex. Hair containing a high concen- tration of melanin (eumelanin) will appear brown or black whereas hair with a low concentration of melanin (pheomelanin) will appear blond or red. Hair that lacks melanin will appear white or gray. In humans, the density and distribution of pigment is relatively consis- tent throughout the length of the hair shaft, whereas in animal hair, the pigmentation is usually more dense toward the medulla. Animal hair may also show sudden color changes (called banding).

The Medulla

Sometimes the hair shaft has a central layer, or core called the me- dulla. When present, this layer may appear in one of three different patterns: fragmented, intermittent, or continuous (Figure 3). This por- tion of hair can appear quite different from one species to the next and from one individual hair to another. For example, the width of a human medulla is less than one-third the overall diameter of the hair shaft whereas in animals it is generally greater than one-third. It is this variation that helps scientists identify hair from textile fibers and distinguish the species from which hair originated. As seen in Figure 4, there are several types of medulla structu

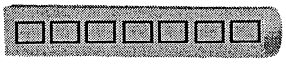
Figure 3
Medulla patterns



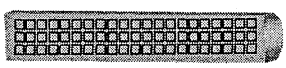
Absent Fragmented Intermittent Continuous

Figure 4 Medulla Structures

Uniserial



Multiserial



Vacuolated 

Lattice 

Amorphous 

Human vs. Animal Hair

In order to distinguish human hair from hair of other mammals, one must first be familiar with the some general characteristics of human and animal hair. For example, human hair usually exhibits an imbri- cate scale pattern, whereas animal hair can have a spinous or coronal scale pattern as well. In addition, just as humans can have a number of different hair types (facial, limb, pubic, etc.), animals can generally possess up to three different hair types. These hairs are classified ac- cording to their location and function (guard hairs, ground hairs, and tactile hairs). Guard hairs form the outer coat of an animal and are usually course, straight, and taper to a point. Ground hair, or underfur, is fine, soft, kinked, and closely spaced. When the underfur is matted together, the coat is called wool. Tactile hair (whiskers or vibrissae) are long, thick and stiff. These unique characteristics make it possible for experts in the field to differentiate between breeds and types of animals and may become useful in an investigation.

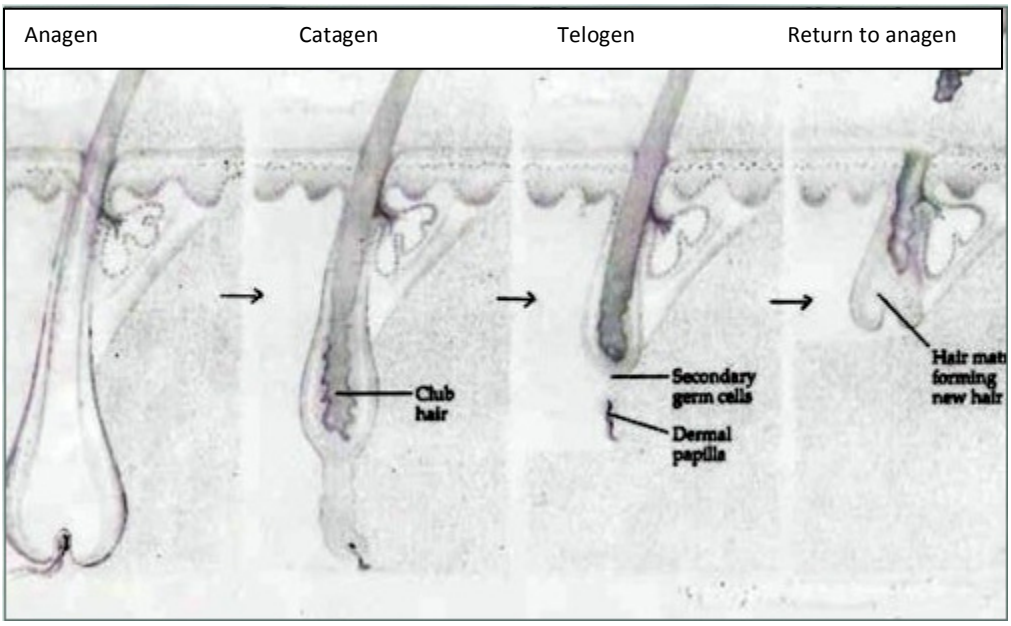
Hair Shape

When human hair is cut and viewed in cross section, it will either ap- pear circular, oval, or flattened (Figure 5). A forensic examiner recog- nizes the correlation between hair shape and racial origin. Straight hair appears circular in cross-section, and is characteristic of Asian ancestry (Mongoloid race). Hair that appears more oval in cross- section is characteristic of European ancestry (Caucasoid race), and hair that appears flattened in cross-section is characteristic of African ancestry (Negroid race).

Growth Phases and Root Appearance

When examining hair evidence it is also beneficial to be able to rec- ognize the developmental stage of growth the hair was in at the time of being shed or removed from the body. This can be accomplished by examining the shape and size of the hair root. If the hair was in its initial growth (anagen) phase, the root bulb would appear flame- shaped. If the hair was forcibly removed during this phase, it would also have a translucent piece of tissue surrounding the shaft of the hair near the root (Figure 6a). This tissue, known as a follicular tag, contains the richest source of DNA associated with hair. If the hair root appeared elongated, it would mean that growth has slowed and has entered the catagen phase of growth (Figure 6b). This transitional phase usually lasts about 2-3 weeks and is the period in which the root bulb

shrinks in size and begins to get pushed out of the hair folli- cle. If the root appears club-shaped (Figure 6c), the hair would be considered to be in its final stage of development, the telogen phase. This stage lasts from a period of 2-6 months and is when hair natu- rally falls out of the skin.



http://www.dermhairclinic.com/articles-los-angeles-follicular-unit-extraction/articles-the-importance-of-hair-cycles-and-body-hair-extraction/

When human or animal hair is recovered from a crime scene, the microscopic morphological characteristics of each sample provide strong corroborative evidence for placing an individual at the site. The variability and distribution of the microscopic characteristics are useful in determining whether or not a questioned hair could have originated from a particular individual. It should be noted, however, that hair can only be considered class evidence (unless DNA has been extracted from it) because it is impossible to conclusively link the hair to any one individual. There are simply too many morphological characteristics that vary from one person (or animal) to another, and within a single individual, to prove identity.

Purpose/Objectives:

Hairs and Fibers

- Become familiar with the morphological characteristics of hair
- Differentiate between human and non-human hair
- Classify fibers based on microscopic observations
- Utilize your knowledge to analyze questioned samples and arrive at conclusions
- Learn about some of the techniques used be trace evidence examiners

Materials:

Hairs and Fibers

Human hair samples
Animal hair samples
Fiber samples
Slides and Cover Slips
Compound microscope
Colored Pencils

Lab Procedures:

Monitor your time closely. If some students/groups are starting with Part 1, other groups can start with Part 2.

Part 1. Fiber Analysis

You may need to temporarily mount your fiber/hair on a glass microscope for viewing. To do this, place the hair on a glass microscope slide and place a small drop of water on the fiber/hair. Place a coverslip over the fiber/hair and observe the listed characteristics.

Assessing Morphological Characteristics

1. Examine each fiber sample you've been given starting with the lowest objective of a compound microscope and moving up to the highest. In Table 1 of the Analysis section, sketch your observations using the 40X objective and comment on the following:

- Color, including color variations
- Texture (rough, smooth)
- Shape (flat, twisted, coiled, etc…)
- Presence/absence of striations (lines) on the fiber

Part 2. Hair Analysis

Assessing Morphological Characteristics

1. Examine each hair sample you've been given starting with the lowest objective of a compound microscope and moving up to the highest. In Table 2 of the Analysis section, sketch your observations using the 40X objective and comment on the following:

- Form: Straight, wavy, curly, or tightly coiled?
- Color(s): Black, brown, red, blonde, gray, dyed or multicolored (banded)?
- Medulla structure & Medulla pattern: Uniserial, multiserial, vacuolated, lattice, amorphous, fragmented, intermittent, continuous

- Root Structure: tissue (follicular tag) present, absent, or N/A
- Medullary Index

The medullary index measures the diameter of the medulla relative to the diameter of the hair shaft and is usually expressed as a fraction. It is used to distinguish animal hair from human hair. Humans have a medullary index of 1/3 or less i.e. the medulla takes up ~1/3 or less of the diameter of the hair shaft. The medullary index of animals is 1/3 or greater. Determine the medullary index of each hair.

- Scale pattern (Coronal, spinous, Imbricate)
- Additional Characteristics (Burnt, damaged, debris present, etc.)

Part 3. Answer the Assessment Questions

Part 4. Lab clean-up and notebook signing

Unplug and recover your microscopes. Make sure you have made all necessary observations and sketches in your notebook & that you have written a conclusion. Make sure to have your notebook signed by your instructor before you leave.