

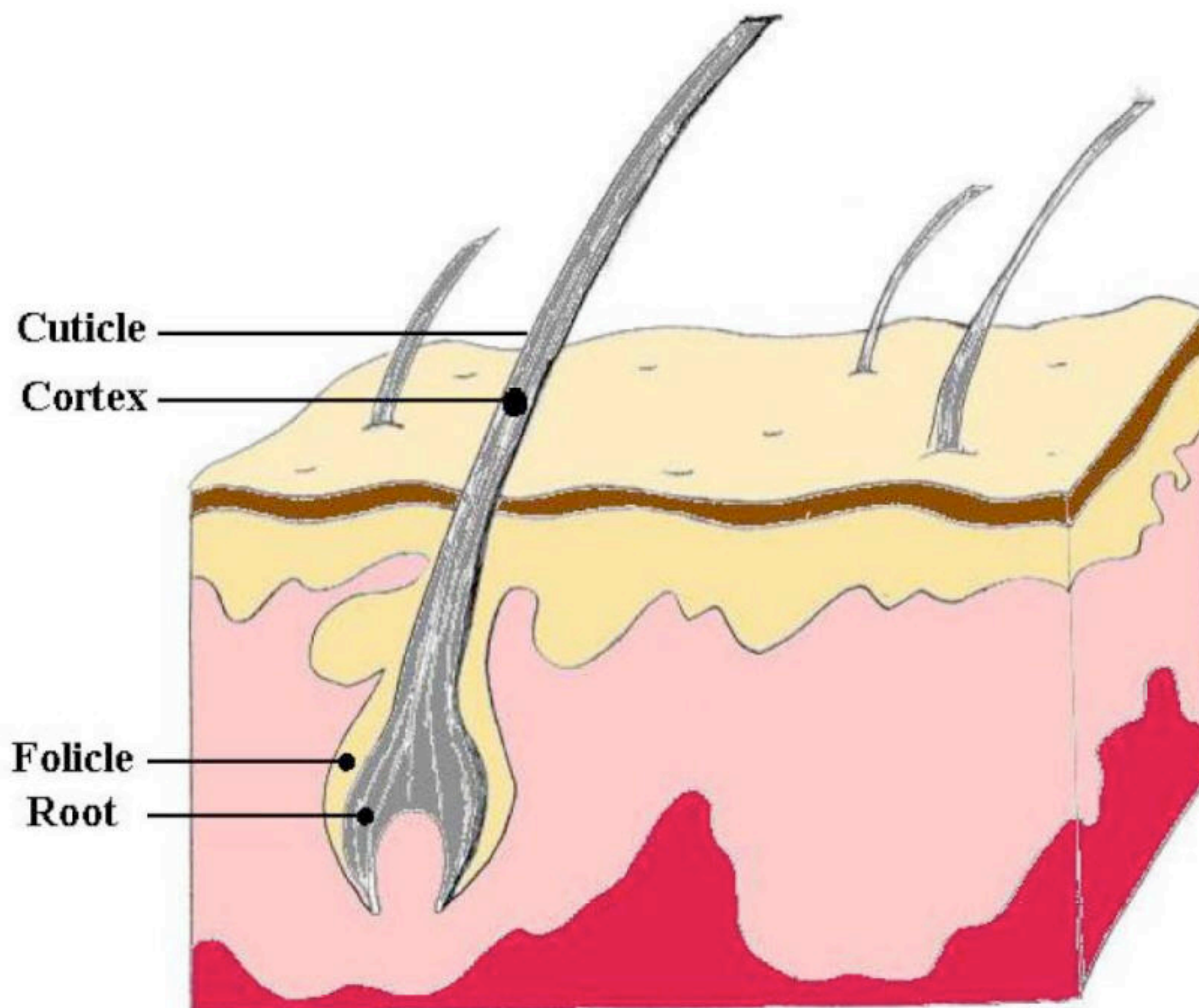
Hair & Fiber

(Unit 5)

Morphology of Hair

Hair is encountered as physical evidence in a wide variety of crimes. A review of the forensic aspects of hair examination must start with the observation that it is often difficult to individualize a human hair to a single head or body. If a hair is forcibly removed in such a way to leave some blood or skin with the root, then DNA typing can be performed. There are also some new techniques which allow DNA typing to be performed without a root, if an ample number of hairs are found.

In the absence of a root with skin or blood, or a sufficient sample of hairs, color and structure (*morphology*) is the most characteristic forensic feature of hair. If hair is properly collected at a crime scene and accompanied by an adequate number of control hairs, it can provide strong corroborative evidence for placing an individual at a crime site. Hairs can also give assistance by giving clues as to how a hair came to be removed from its source. It is quite easy to distinguish between hairs that have been forcibly removed, cut, or have simply fallen out.

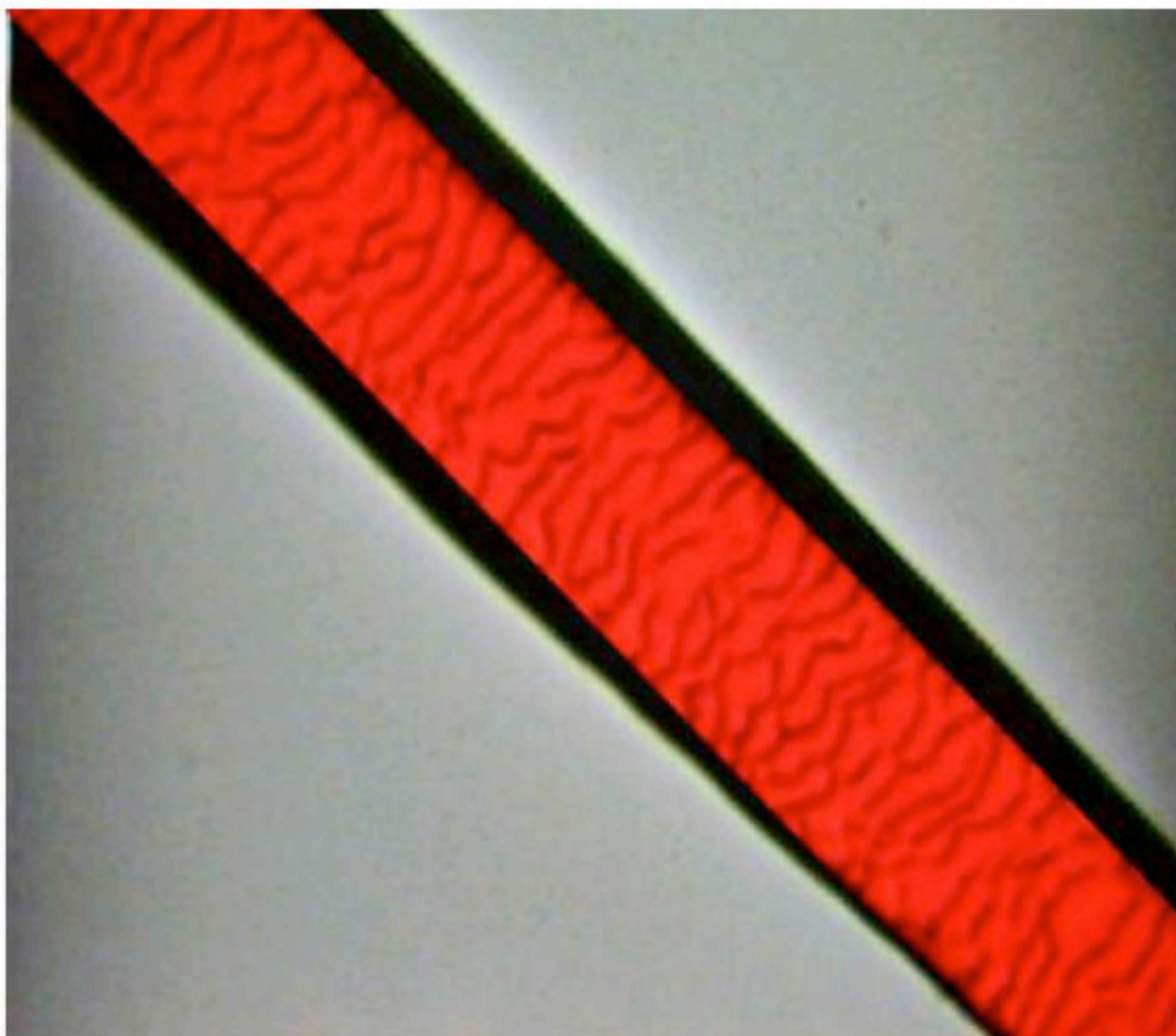


Hair is an appendage of the skin that grows out of a structure known as the *hair follicle*. The length of a hair extends from the *root* embedded in the follicle, continues into a *shaft*, and terminates at the *tip*. The shaft itself, which is composed of cuticle, cortex, and medulla, is subjected to the most intense examination by the forensic scientist. Most hair observations, with the exception of the cuticle, can be performed with a simple microscope. Simply place a hair on a slide with a drop of water, then top with cover slip. Now, with some careful adjustments to the light source and focus, excellent properties of the medulla, cortex, and condition of the hair may be determined.

Cuticle Characteristics

Two of the features that make hair a good subject for establishing individual identity are its resistance to chemical decomposition and its ability to retain structural features over a long period of time. Much of this resistance and stability is attributed to the *cuticle* or outside covering of the hair. The cuticle is formed by overlapping scales that always point toward the tip of the hair. The scales are formed from special cells that have hardened and flattened while progressing from the follicle.

In most situations additional steps must be taken to observe the cuticle of any hair. The quickest and cheapest way of accomplishing this is molding. Hair molds can be made by placing a layer of clear fingernail polish or soft vinyl on a slide, then laying a hair on top of the polish. Once the polish dries, the hair is removed leaving a mold of the cuticle to be observed under a microscope. Below is a picture of a hair mold, which has been digitally colored to highlight the cuticles.



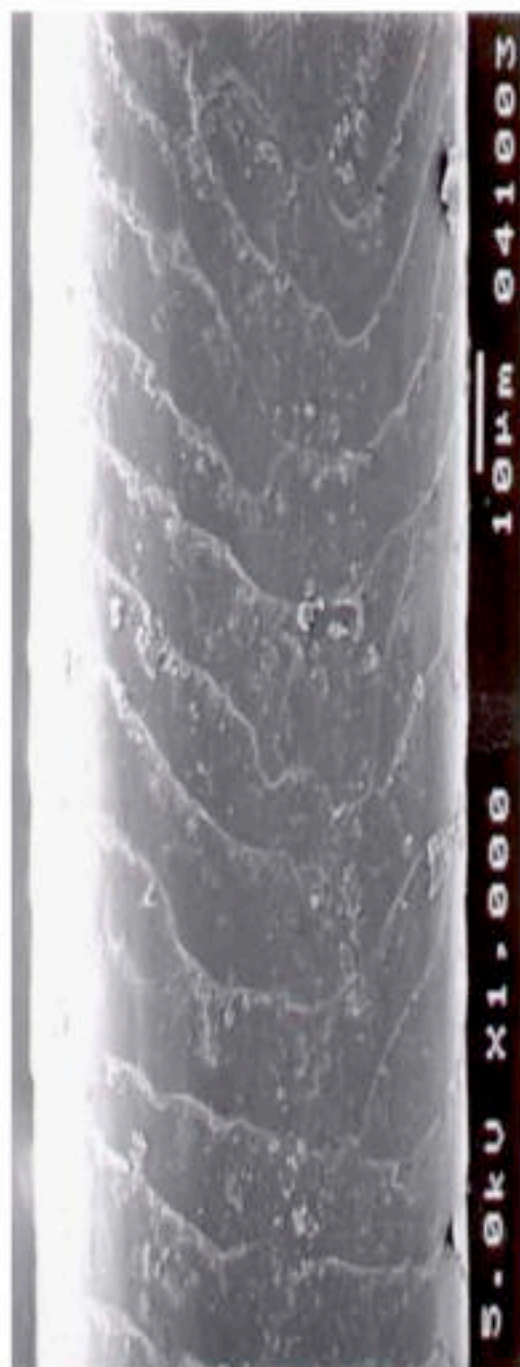
The only other effective way of examining a cuticle is with the aid of an electron scanning microscope. These devices are extremely expensive to purchase and maintain. The scales of most animal hair can best be described as having the appearance of shingles on a roof. The different scale patterns formed on animal hairs are important features for species identification. The figures on the following page show the scale patterns of some animal hairs as viewed by an electron scanning microscope.



Pig



Cow



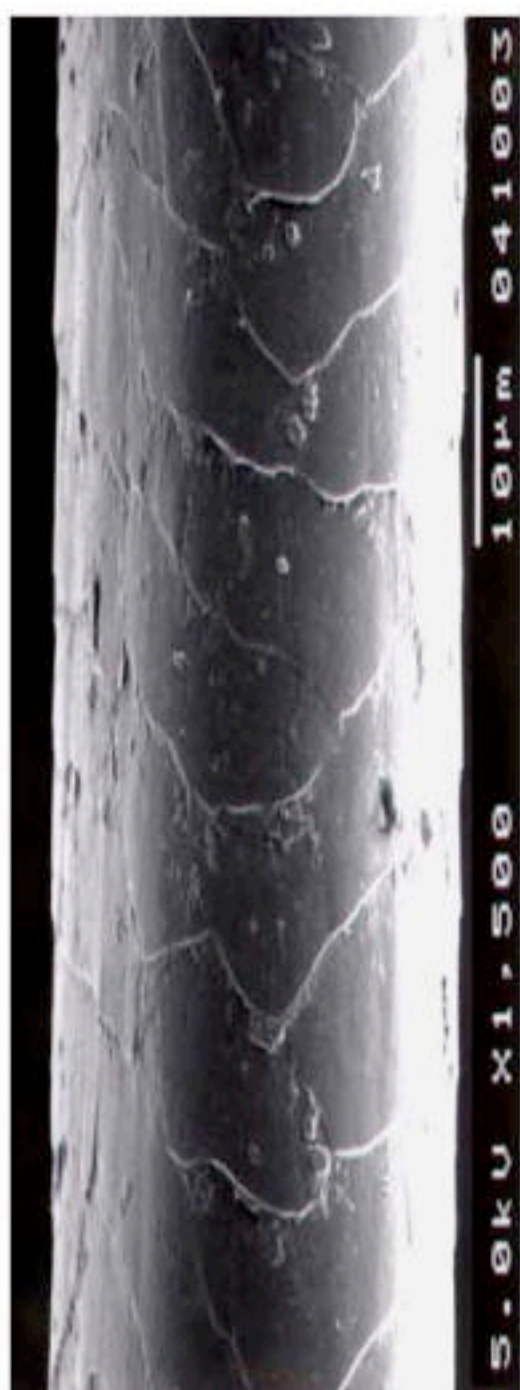
Squirrel



Mouse



Dog



Cat



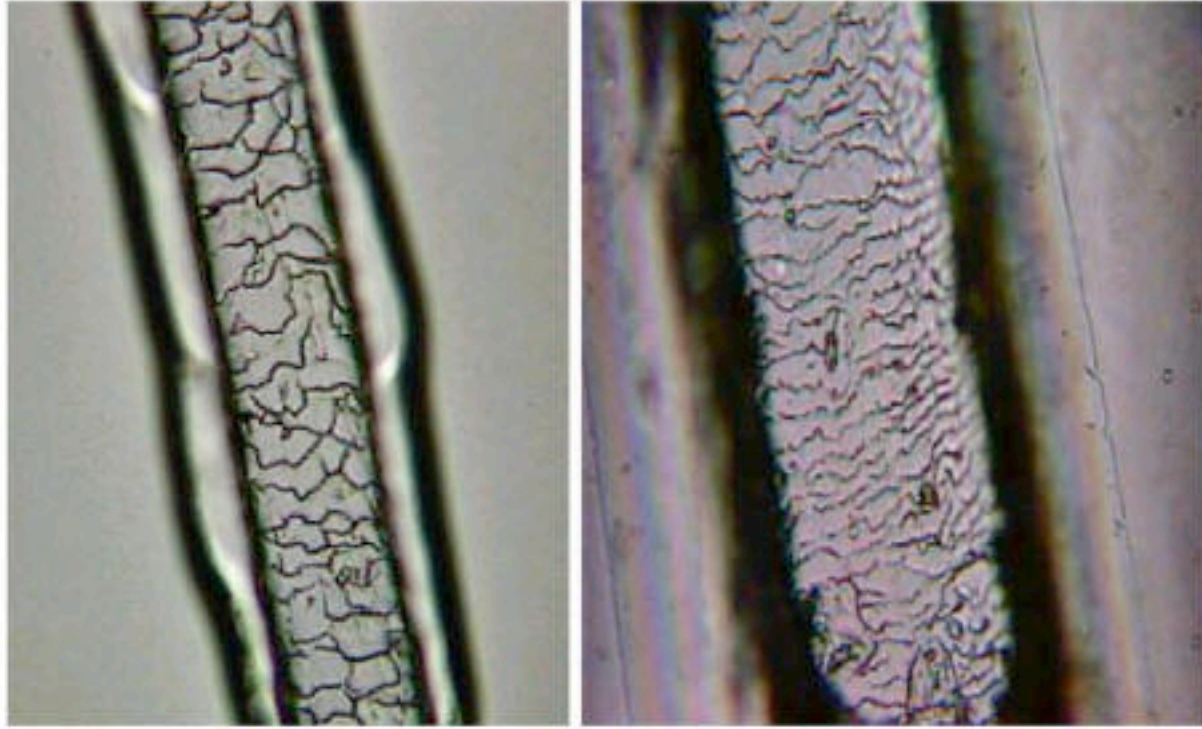
Deer



Rabbit



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In the hair mold pictures to the left the difference can be seen between the cuticles of dog and human hair. The left strand is dog hair and the right is human. Below are some examples of human hairs as seen through an electron scanning microscope.



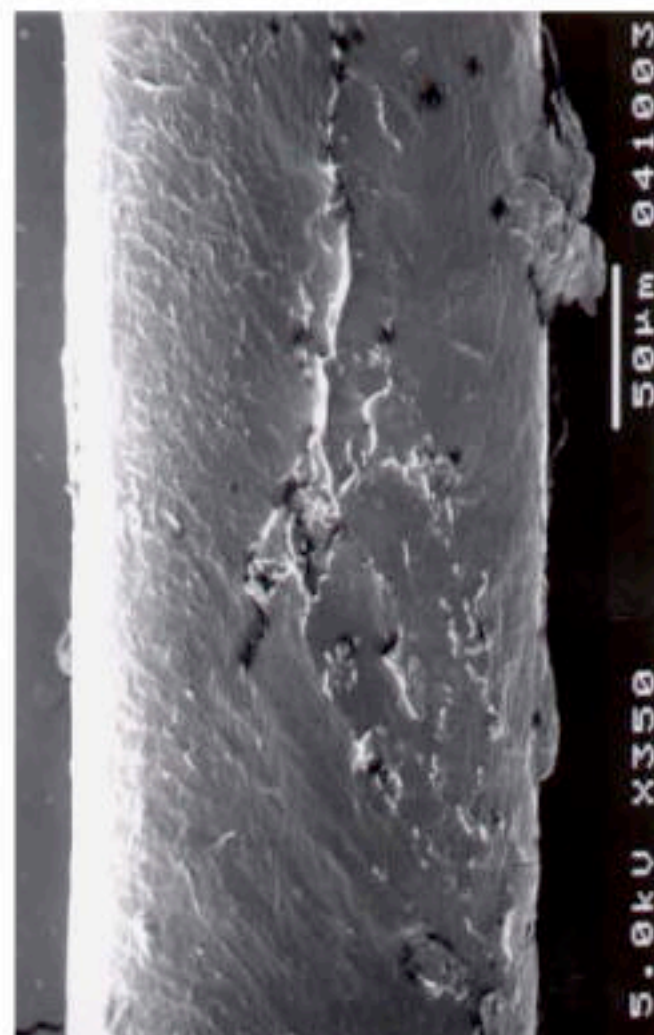
Head Hair



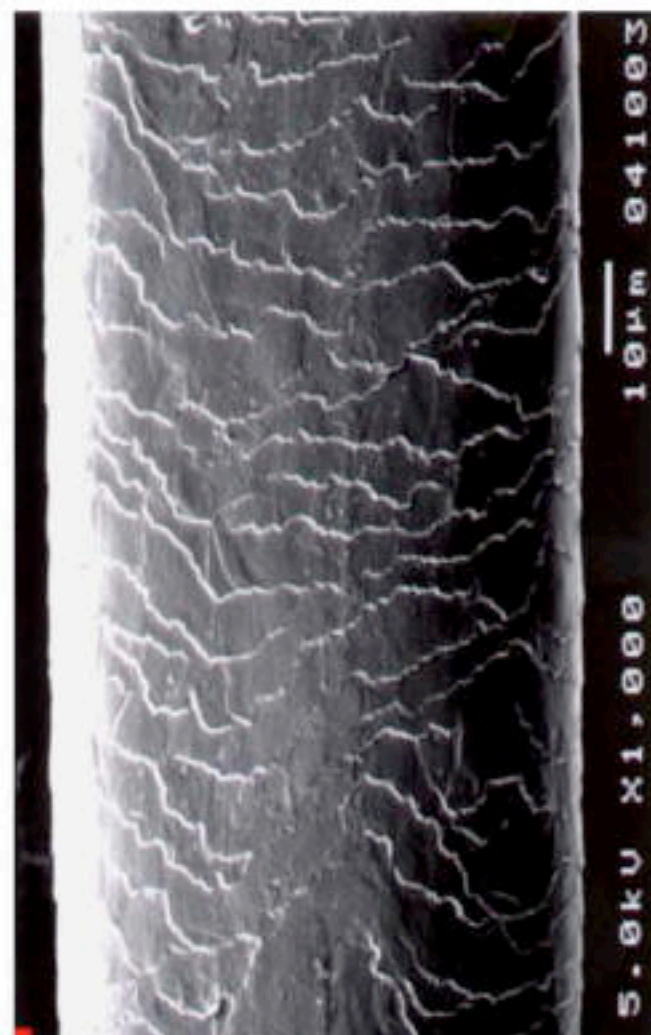
Head Hair (Dyed)



Head Hair (with Gel)



Mustache Hair (with Wax)



Arm Hair

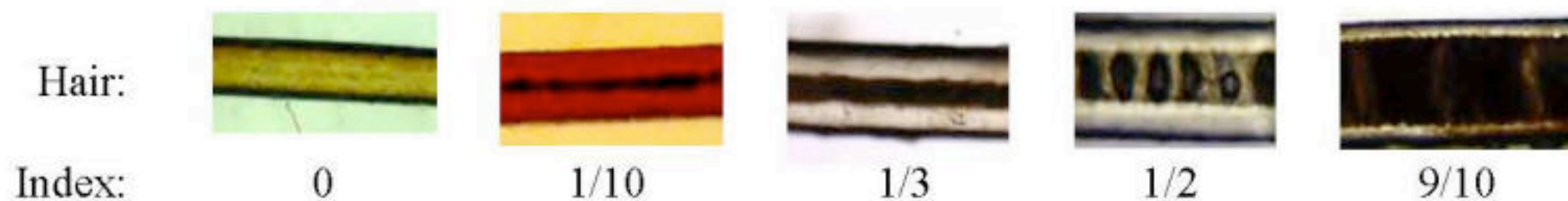


Pubic Hair

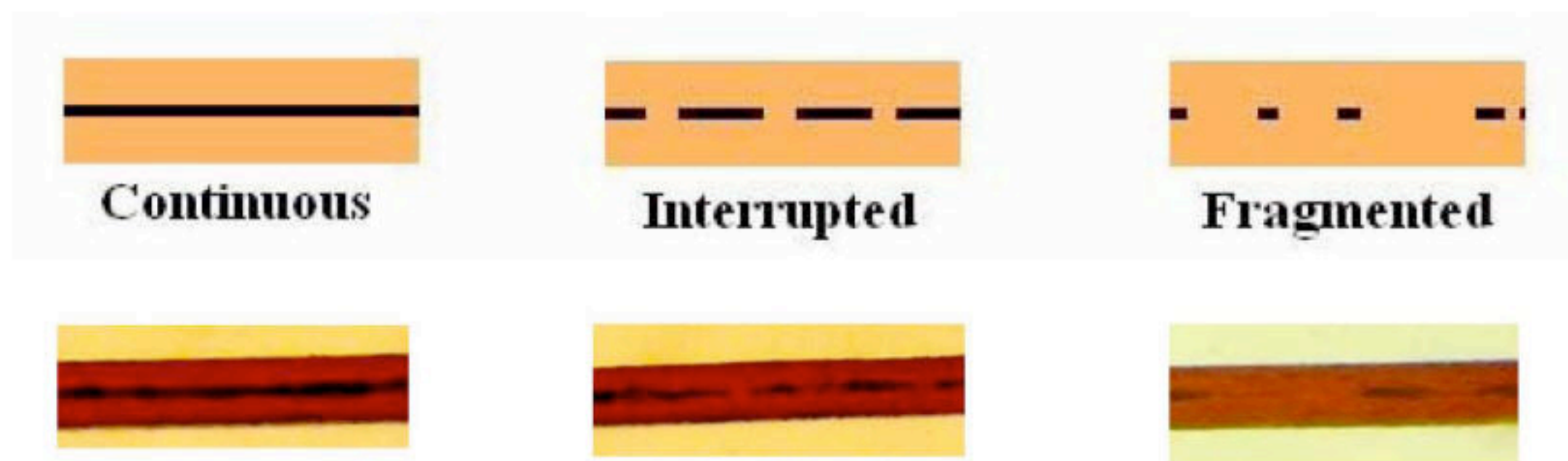
Contained within the protective layer of the cuticle is the cortex. The *cortex* is the interior of the hair, which is composed of spindle-shaped cortical cells aligned in a regular array, parallel to the length of the hair. The cortex derives its forensic importance from the fact that it is embedded with pigment granules that impart color to hair. It is the color, shape, and distribution of these granules that provide points of comparison between the hairs of different samples. The features of the cortex are examined microscopically after a hair has been placed on a slide with a couple of drops of water and a cover slip.

Medullary Characteristics

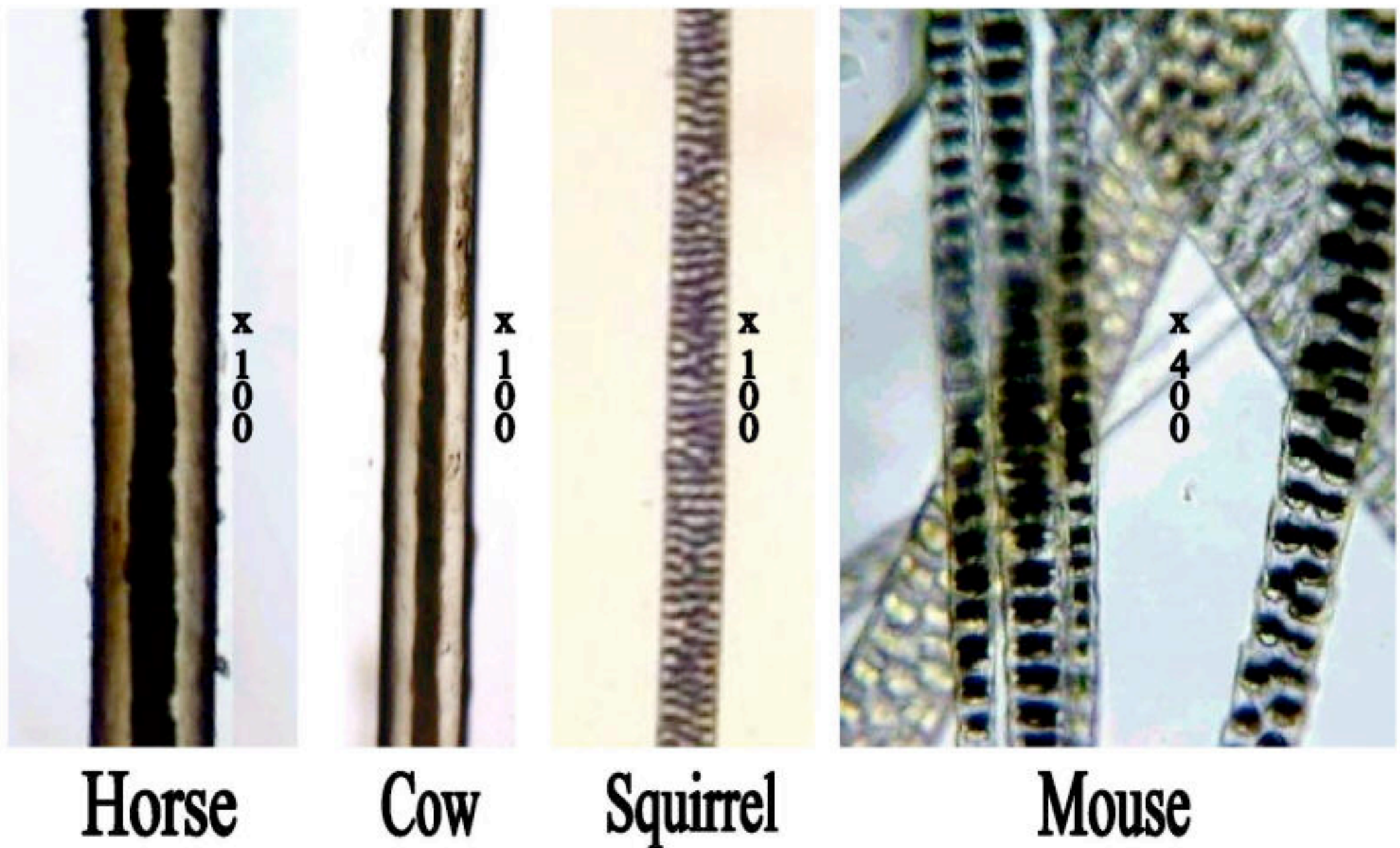
The *medulla* is a collection of cells which appear as a canal running through the center of the hair. In many animals, the medulla is the most predominant feature, sometimes spanning more than half of a hair's diameter. The *medullary index* is an estimate of the width of the hair taken up by the medulla; it is usually expressed as a fraction. The index generally has a value less than $1/3$ for humans; for most other animals the value is $1/2$ or greater.



Not all human hairs have a medulla. When present, the appearance of the medulla varies slightly between a single individual's hairs. Appearance can vary significantly from one individual to another. In this respect, medullae may be classified as being continuous, interrupted, fragmented, or absent (see the figure below). Human head hairs generally exhibit no medullae or have fragmented ones; they rarely contain a continuous medulla. One exception is the *Mongoloid* race. Mongoloids head hairs usually have a continuous medulla.



Most animals have medullae that are either continuous or interrupted. Although the features of medullae are similar among species, there are many variations which occur within the same animal. General shape of the medulla, the most common feature used to identify a species, holds true within a sub-species.

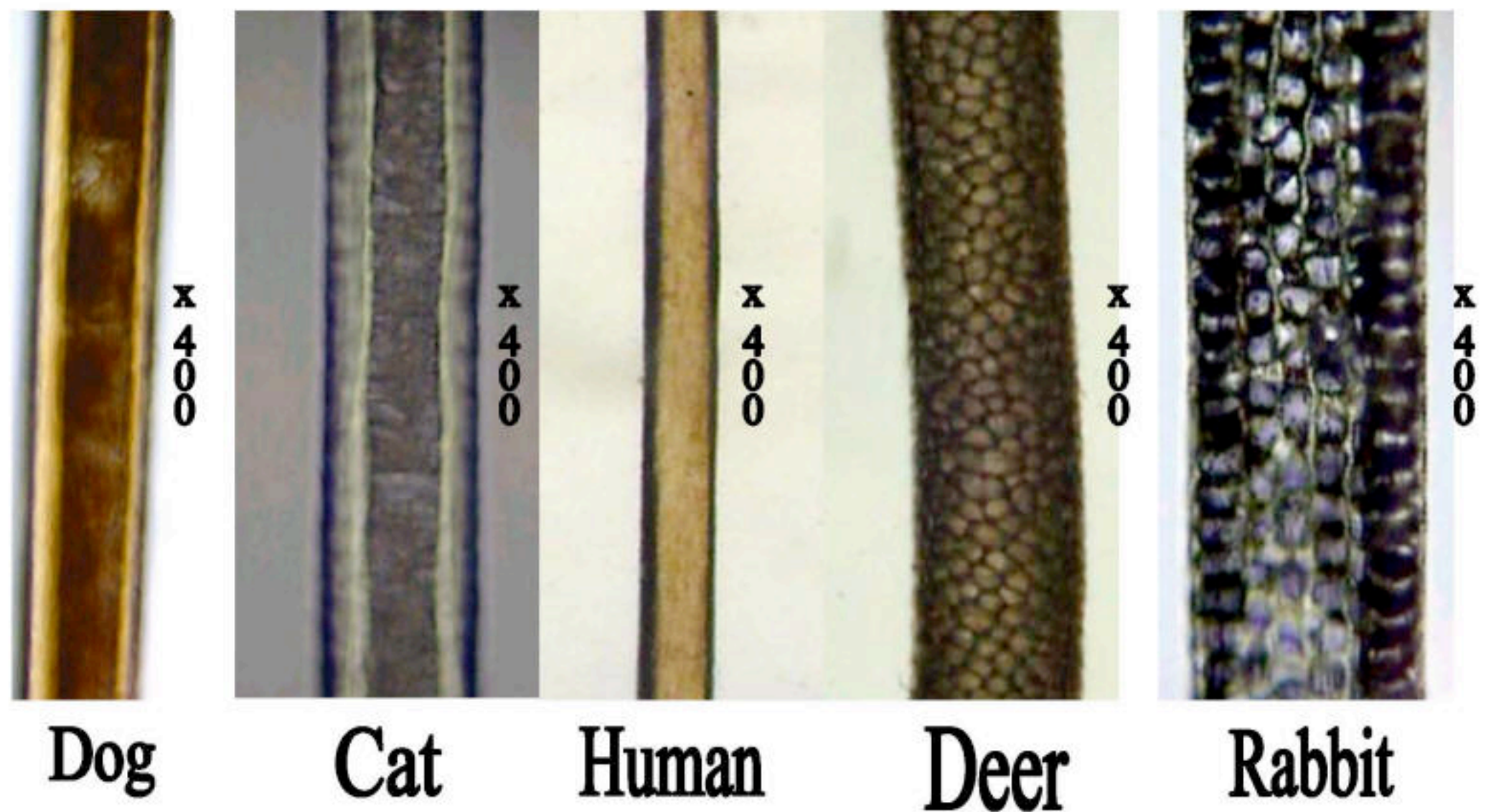


Horse

Cow

Squirrel

Mouse



Dog

Cat

Human

Deer

Rabbit

Humans, as well as many animals, have medullae that appear nearly cylindrical. Other animals' medullae have a patterned shape. For example, the medulla of squirrel hair appears to be small sticks stacked horizontally and randomly on top of one another. Deer hair appears as oddly shaped spheres crowded close together. The pictures above show some hairs as they may appear under a microscope.

Identification and Comparison of Hair

Upon finding hair at a crime scene, the first thing to be done is an examination in a crime laboratory to establish whether the hair originates from a human or animal. If human, the hair retrieved at the crime scene should be compared with hair from suspects and victims. Although the distinction of animal hair from human hair can normally be accomplished with little difficulty, the problem of human hair comparisons is one that must be undertaken with extreme caution. Hairs have a tendency to exhibit variable characteristics, not only from one person to another, but also within a single individual.

A careful microscopic examination of hair will reveal morphological features that can distinguish human hair from that of animal hair. Before such a conclusion is reached, the examiner must have access to a comprehensive collection of controls. Scale structure, medullary index, and medullary shape are features that are particularly important in matching hair samples.

The most common request made of the laboratory when hair is used as forensic evidence is to determine whether or not hair recovered at the crime scene is of the same origin as hair removed from a suspect. In most cases, such a comparison relates to hair obtained from the scalp or pubic area. In the absence of skin and blood on a root, or enough hairs to perform DNA testing, this distinction can only be made with some degree of probability.

In comparing hairs, it is particularly important to match the color, length, and diameter of the hairs. Other important features are the presence or absence of a medulla and the distribution, shape, and color intensity of the pigment granules present in the cortex. A microscopic examination may also be able to predict if a hair has been dyed or bleached. If there has been a growth of hair since a hair was bleached or dyed, then it is possible to estimate the time passed since coloring. Hair is known to grow at a rate of approximately one centimeter (1 cm) per month. A dyed or colored hair is usually colored throughout the cortex. Bleaching, however, completely removes the pigment from hair which gives it a yellowish tint. In contrast, naturally-colored hair usually contains granules with a texture similar to picture colored by a crayon. A hair that has been dyed or artificially colored, displays a smooth uniform color similar to tinted glass. The one exception is grey hair, which appears clear due to the complete absence of pigment.

In the absence of DNA typing, it is estimated that if one human head hair found at the scene of a crime is similar to a representative hair from a suspect's head, the odds against it originating from another person are about 4500 to 1. The odds against two similar pubic hairs originating from two different individuals are about 800 to 1. Because Negroid and Mongoloid hairs exhibit less variation in many of their characteristics, it is expected that these odds are somewhat less for persons of these racial origins.

Frequently Asked Question about Hair

Is it possible to determine where on a human body a hair originated?

In most cases, it is quite easy to identify where on a body a hair originated, even more so when several hairs are available. Head hair has a smaller diameter than hair from the rest of the body and is more evenly colored. Hair from the legs and trunk contain more medulla than head hair, and exhibit a less uniform distribution of pigment. Pubic hairs are short, curly, and have a much more pronounced medulla. Facial hair is coarse and may have a triangular cross section, with blunt tips as a result of trimming and shaving.

Can the race be determined from the examination of a hair?

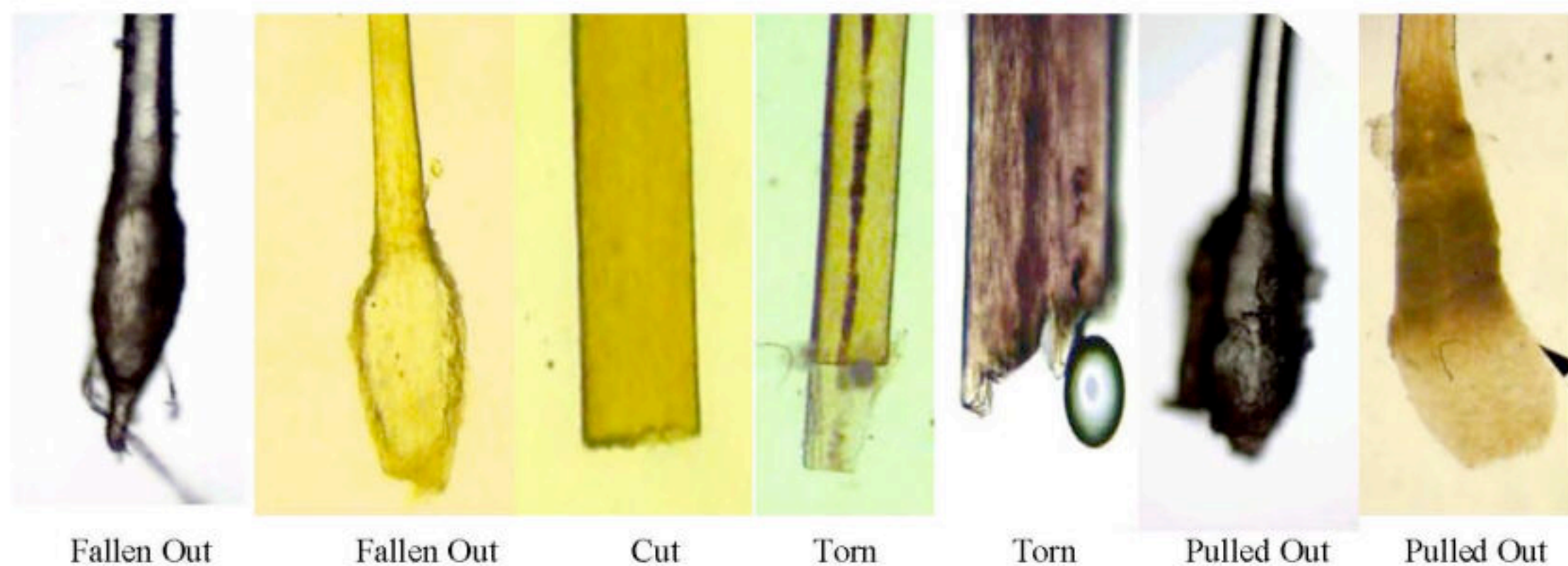
In some cases it is possible to identify the race of an individual through an examination of a hair. This is usually accomplished by observing some general characteristics of the hair from different races. For example, Negroid hairs are normally kinky, containing dense, unevenly distributed pigments. Caucasian hairs are straight or wavy, with very fine to coarse pigments that are more evenly distributed when compared to Negroid hair. Sometimes a cross-sectional examination of hair may also aid in the identification of race. Cross sections of hair from Caucasians are oval to round in shape, whereas cross sections of Negroid hair are flat or oval in shape. Due to the lack of pure genealogies in the United States, these observations are trivial at best. However, if an adequate sample is present to perform an examination of the DNA, then specific information may be determined about the donor's racial origin, and the origin of his ancestors.

Can the age or sex of a person be determined by examining their hair?

The age of an individual cannot be determined from a hair examination, except with infant hair. Infant hairs are fine, short in length, and have fine pigment. In the past, the dyed or bleached hair may have suggested hair from a female. But, present hairstyles make these conclusions less likely. The recent development of mtDNA (mitochondrial DNA) analysis has made it possible to determine the sex of an individual by the examination of a single hair. However, because the procedure is so time consuming and expensive, it is not often utilized. If a hair has attached skin or blood, or is accompanied by several hairs, then DNA can be used to determine the sex of the suspect.

Is it possible to determine if hair was forcibly removed from the body?

A microscopic examination of the hair root may establish whether the hair has fallen out or has been pulled out of the skin. A hair root found to have follicular tissue (root sheath cells) adhering to it, as shown on the following page, is indicative of a hair that has been pulled out. Hair naturally falling off the body will show a bulbous-shaped root, free of adhering tissue. However, the absence of sheath cells cannot always be relied upon for correctly judging whether or not hair has been forcibly pulled from a body. In some cases the root of a hair may be devoid of adhering tissue even when it has been pulled from the body. An important consideration is how quickly the hair is pulled out of the head. Hairs pulled quickly from the head are much more likely to have blood or skin as compared to hairs which have been removed slowly.



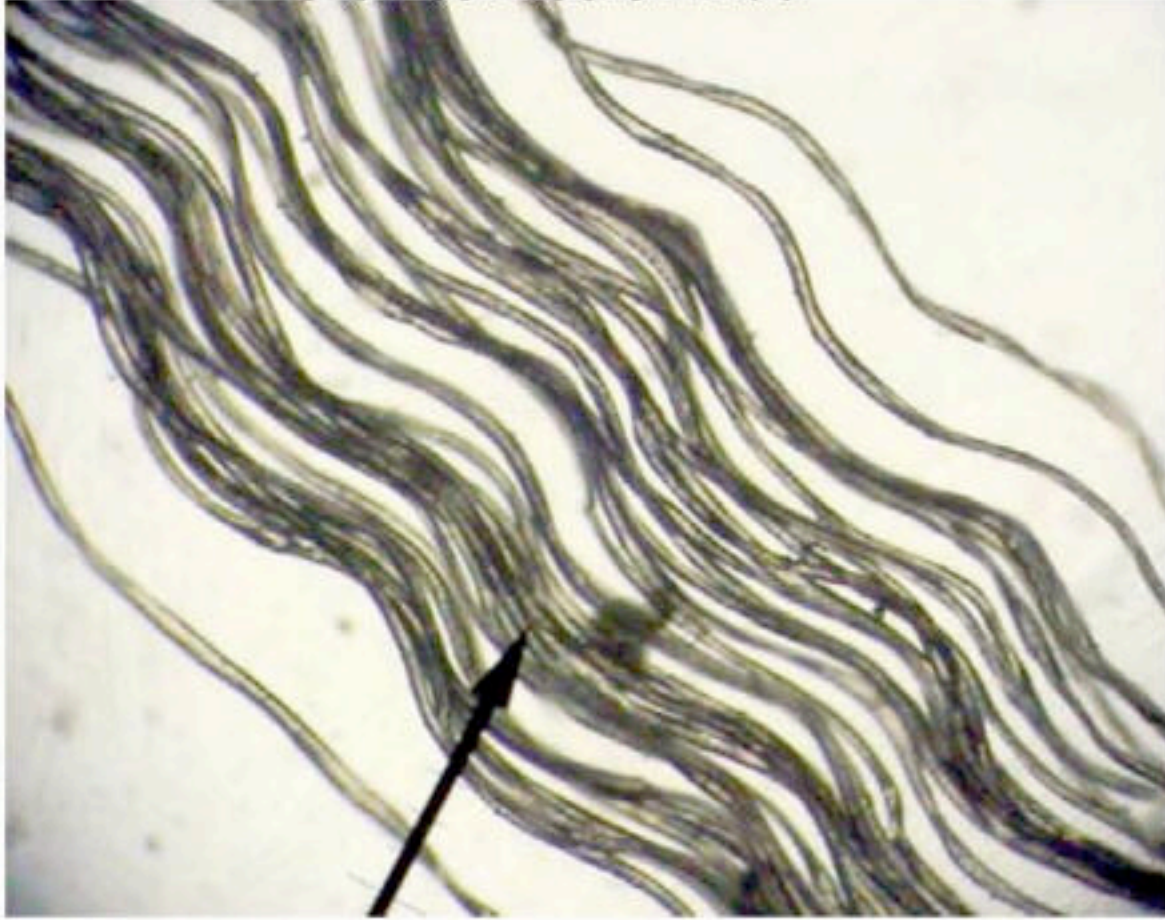
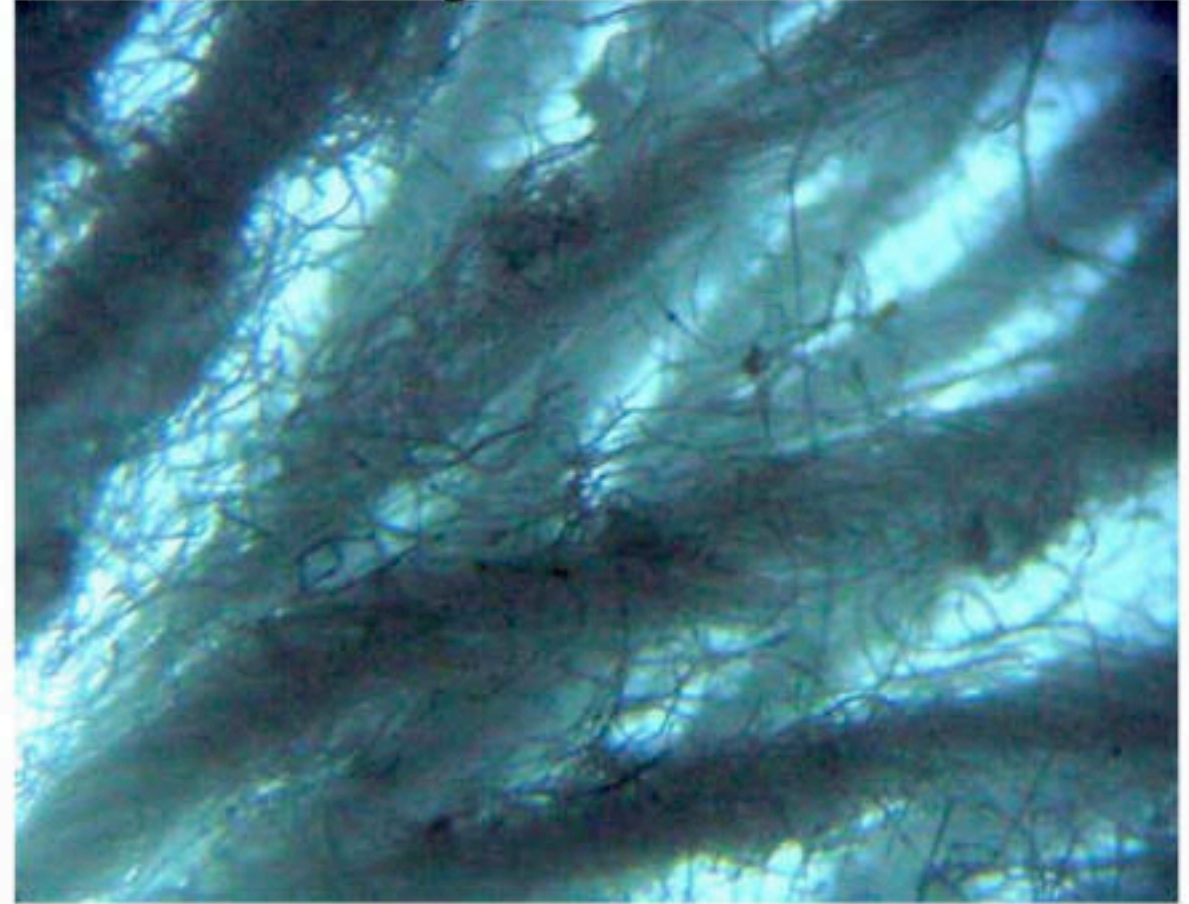
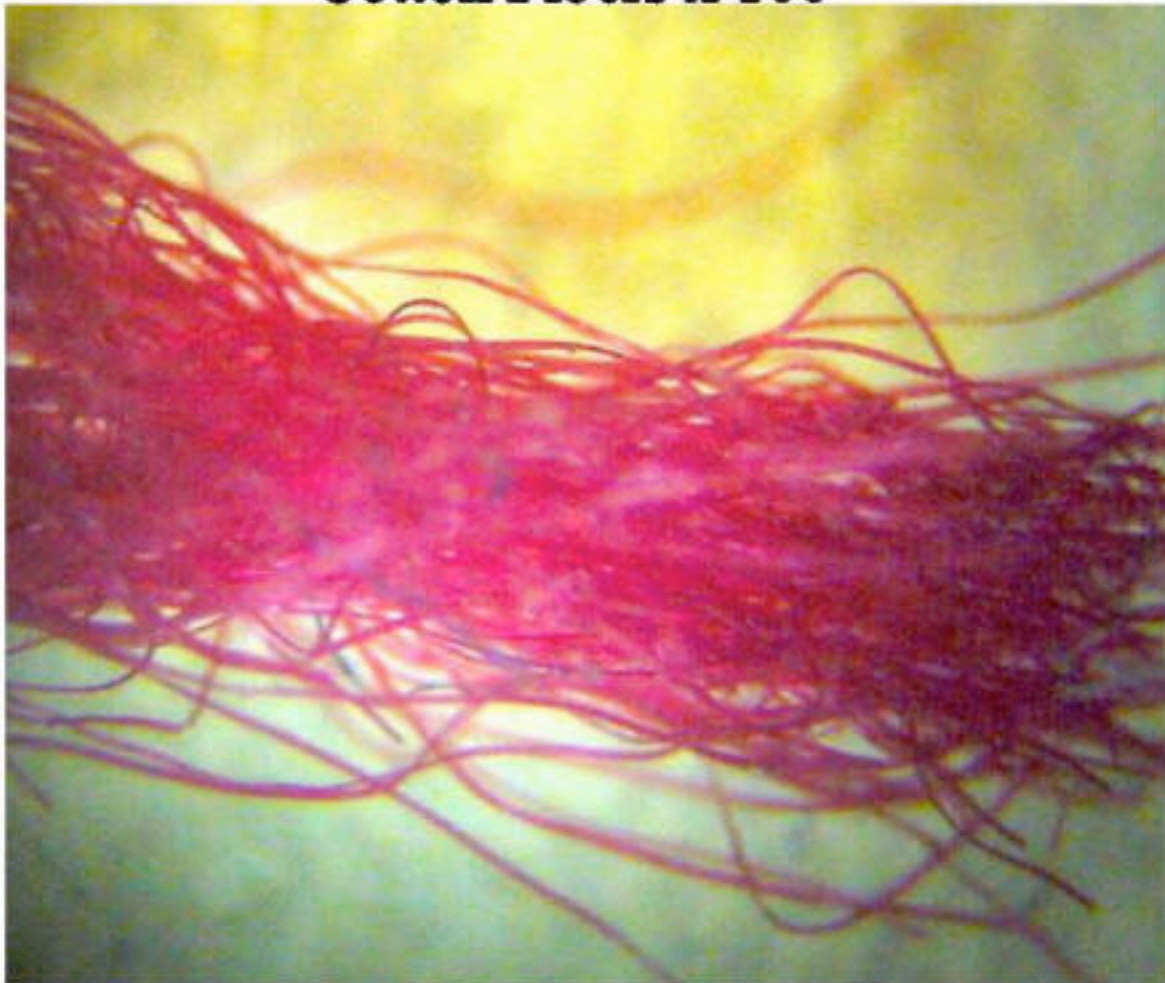
With the exception of mitochondrial DNA, it is not possible to extract DNA from a single hair without blood or skin attached. Such a sample is referred to as a follicular tag. This would make the identification of a person by their hair almost exact. The present process is very sensitive, contamination and mishandling of the hair poses a great threat.

Fibers



Fibers are examined in a similar fashion as hairs. Although fibers do not exhibit the morphology of hairs, they have a range of individual characteristics. Industry has produced a wide variety of natural and synthetic materials. This helps in identifying fibers, for it is likely that matching fibers have the same origin.

Even in the absence of control fibers to which a sample can be compared, a suspect fiber has much to offer. Examining a lone fiber can yield information such as color and possible origin. An experienced observer can immediately identify the type of fiber (synthetic or natural) and a number of possible origins. Below are a few examples of fibers. These are only examples of different types of fibers and are in no way conclusive of the characteristics of each sub-group of fibers.

Clothes Fibers x 100**Carpet Fibers x 100****Cotton Fibers x 100****Synthetic Fibers x 100**

Types of Fibers

Although different types of fibers may come in virtually any color, each specific class of fibers exhibits its own characteristics. Natural fibers, such as cotton, exhibit a more random texture when examined closely.

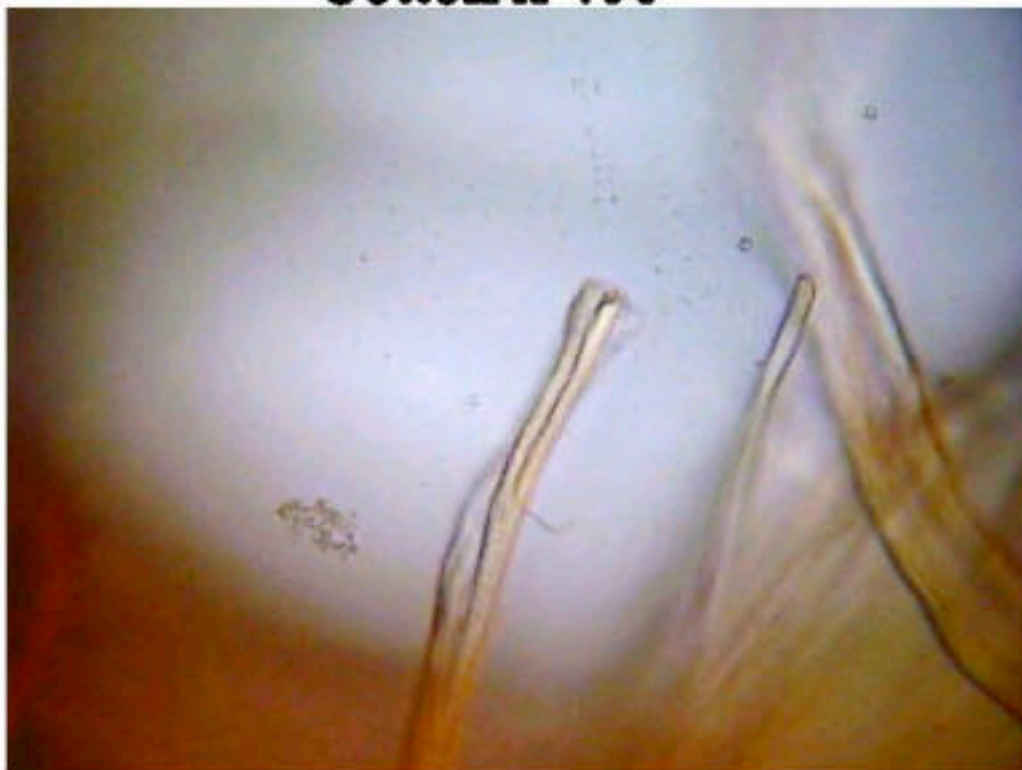
Cotton x 40



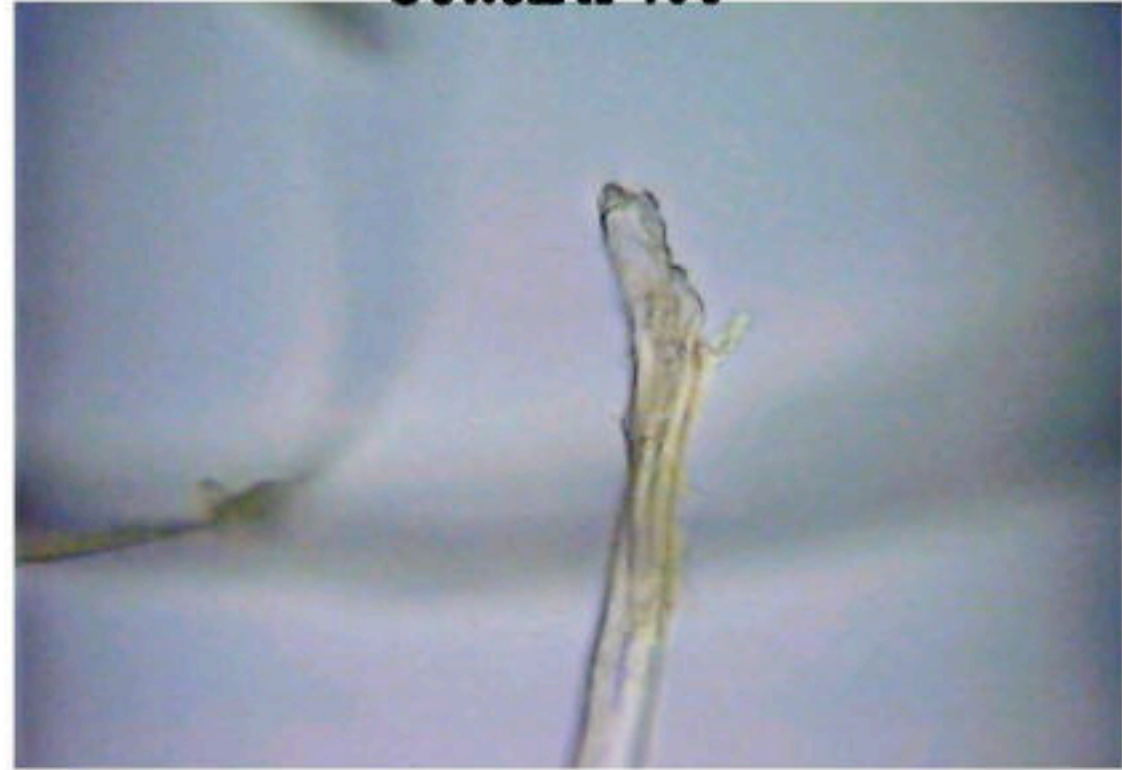
Cotton x 100



Cotton x 400



Cotton x 400



Cotton x 100



Cotton x 400

