

CHEM 107

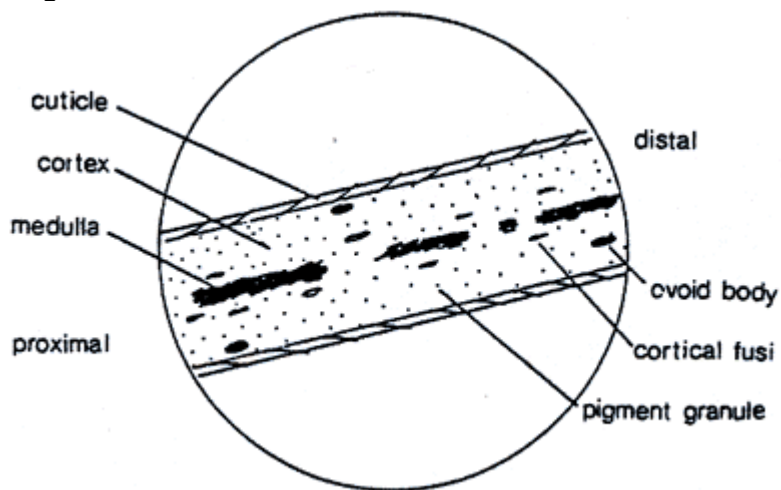
Hair handout.

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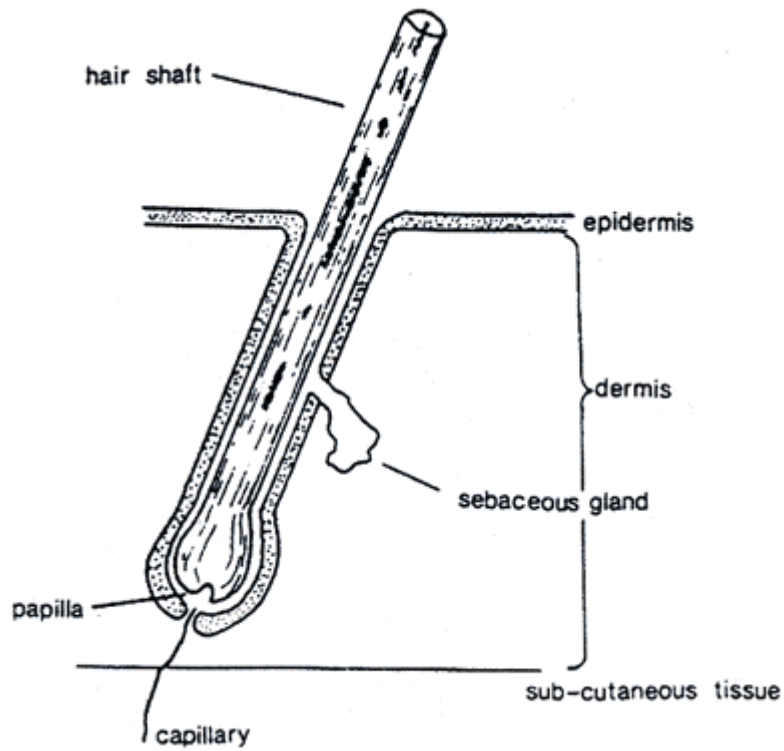
Basic Structure of Hair

A hair can be defined as a slender, thread-like outgrowth from a follicle in the skin of mammals. Composed mainly of keratin, it has three morphological regions—the cuticle, medulla, and cortex. These regions are illustrated in Figure 1 with some of the basic structures found in them. The illustration is a diagram used to emphasize structural features discussed in this guide. Certain structures may be omitted, and others enhanced for illustrative purposes.

Figure 1. Hair Diagram



A hair grows from the papilla and with the exception of that point of generation is made up of dead, cornified cells. It consists of a shaft that projects above the skin, and a root that is imbedded in the skin. Figure 2 diagrams how the lower end of the root expands to form the root bulb. Its basic components are keratin (a protein), melanin (a pigment), and trace quantities of metallic elements. These elements are deposited in the hair during its growth and/or absorbed by the hair from an external environment. After a period of growth, the hair remains in the follicle in a resting stage to eventually be sloughed from the body. **Figure 2. Diagram of Hair in Skin**



Cuticle

The cuticle is a translucent outer layer of the hair shaft consisting of scales that cover the shaft. Figure 3 illustrates how the cuticular scales always point from the proximal or root end of the hair to the distal or tip end of the hair.

Figure 3. Scanning Electron Photomicrograph of Hair



- There are three basic scale structures that make up the cuticle—coronal (crown-like), spinous (petal-like), and imbricate (flattened). Combinations and variations of these types are possible. Figures 4-9 illustrate scale structures. The coronal, or crown-like scale pattern is found in hairs of very fine diameter and resemble a stack of paper cups. Coronal scales are commonly found in the hairs of small rodents and bats but rarely in human hairs. Figure 4 is a diagram depicting a longitudinal view of coronal scales, and Figure 5 is a photomicrograph of a free-tailed bat hair.

Figure 4. Diagram of Coronal Scales

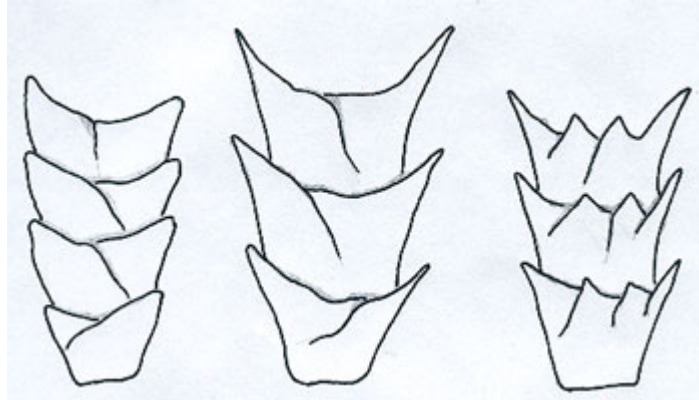


Figure 5. Photomicrograph of Bat Hair



- Spinous or petal-like scales are triangular in shape and protrude from the hair shaft. They are found at the proximal region of mink hairs and on the fur hairs of seals, cats, and some other animals. They are never found in human hairs. Figure 6 is a diagram of spinous scales, and Figure 7 is a photomicrograph of the proximal scale pattern in mink hairs.

Figure 6. Diagram of Spinous Scales

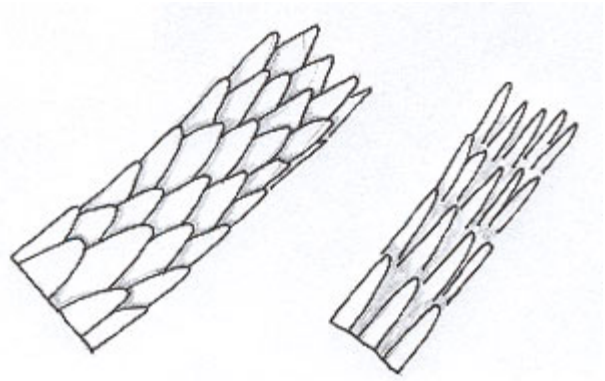


Figure 7. Photomicrograph of Proximal Scale Pattern (Mink)



- The imbricate or flattened scales type consists of overlapping scales with narrow margins. They are commonly found in human hairs and many animal hairs. Figure 8 is a diagram of imbricate scales, and Figure 9 is a photomicrograph of the scale pattern in human hairs.

Figure 8. Diagram of Imbricate Scales

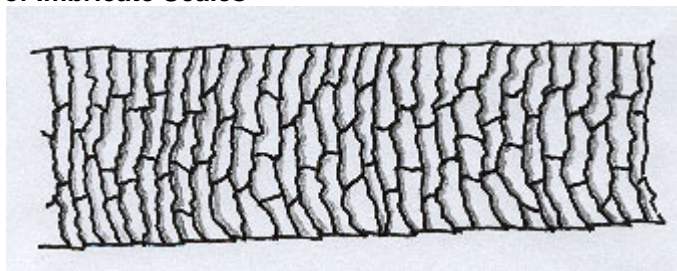
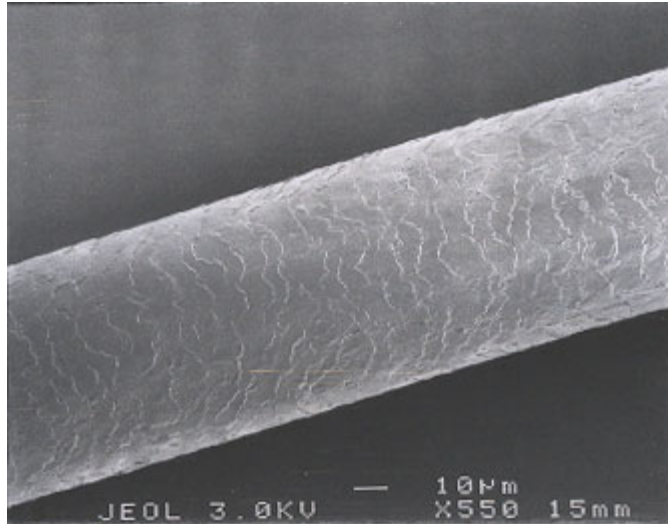


Figure 9. Photomicrograph of Scale Pattern (Human)



Medulla

The medulla is a central core of cells that may be present in the hair. If it is filled with air, it appears as a black or opaque structure under transmitted light, or as a white structure under reflected light. If it is filled with mounting medium or some other clear substance, the structure appears clear or translucent in transmitted light, or nearly invisible in reflected light. In human hairs, the medulla is generally amorphous in appearance, whereas in animal hairs, its structure is frequently very regular and well defined. Figures 10 through 13 are photomicrographs of medullary types found in animal hairs. Figure 10 exhibits a uniserial ladder, and Figure 11 exhibits a multiseriate ladder, both found in rabbit hairs. Figure 12 exhibits the cellular or vacuolated type common in many animal hairs. Figure 13 exhibits a lattice found in deer family hairs.

Figure 10. Photomicrograph of Uniserial Ladder Medulla

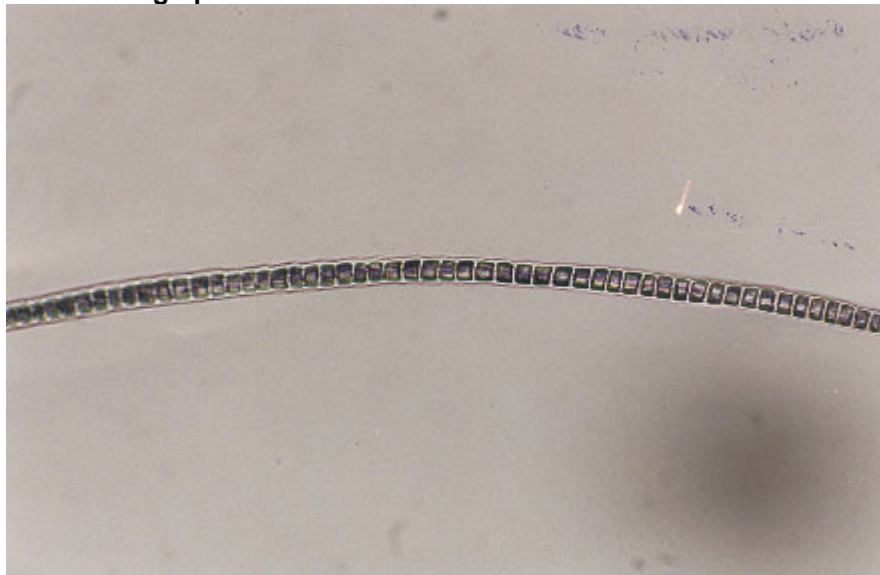


Figure 11. Photomicrograph of Multiseriate Ladder Medulla

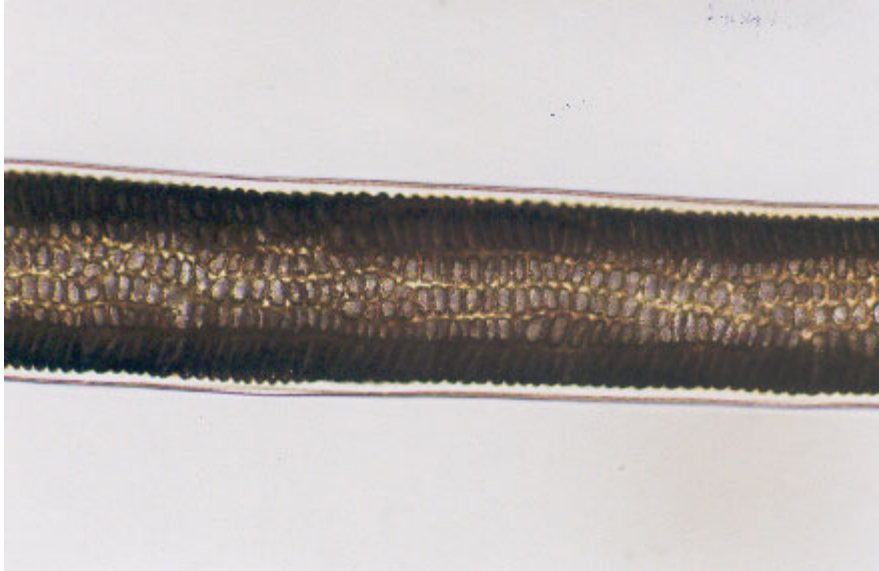


Figure 12. Photomicrograph of Animal Hair

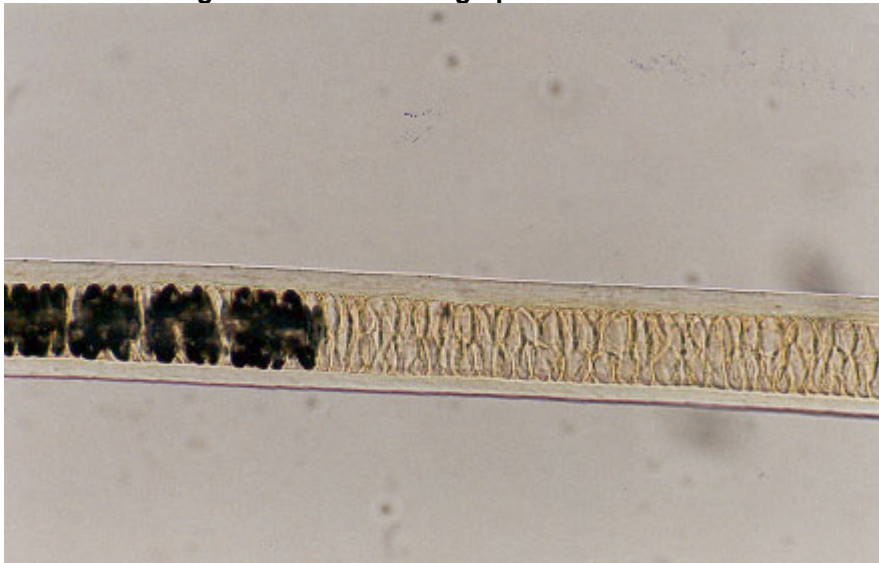


Figure 13. Photomicrograph of Deer Medulla



When the medulla is present in human hairs, its structure can be described as—fragmentary or trace, discontinuous or broken, or continuous. Figure 14 is a diagram depicting the three basic medullary types.

Figure 14. Diagram of Medullas (Trace, top; Discontinuous, middle; Continuous, bottom)

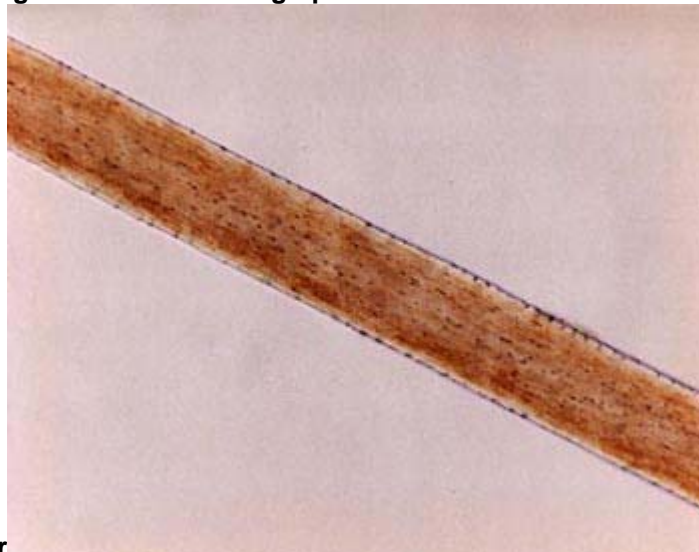


Cortex

The cortex is the main body of the hair composed of elongated and fusiform (spindle-shaped) cells. It may contain cortical fusi, pigment granules, and/or large oval-to-round-shaped structures called ovoid bodies.

Cortical fusi in Figure 15 are irregular-shaped airspaces of varying sizes. They are commonly found near the root of a mature human hair, although they may be present throughout the length of the hair.

Figure 15. Photomicrograph of Cortical Fusi in Human



Hair

Pigment granules are small, dark, and solid structures that are granular in appearance and considerably smaller than cortical fusi. They vary in color, size, and distribution in a single hair. In humans, pigment granules are commonly distributed toward the cuticle as shown in Figure 16, except in red-haired individuals as in Figure 17. Animal hairs have the pigment granules commonly distributed toward the medulla, as shown in Figure 18.

Figure 16. Photomicrograph of Pigment Distribution in Human Hair

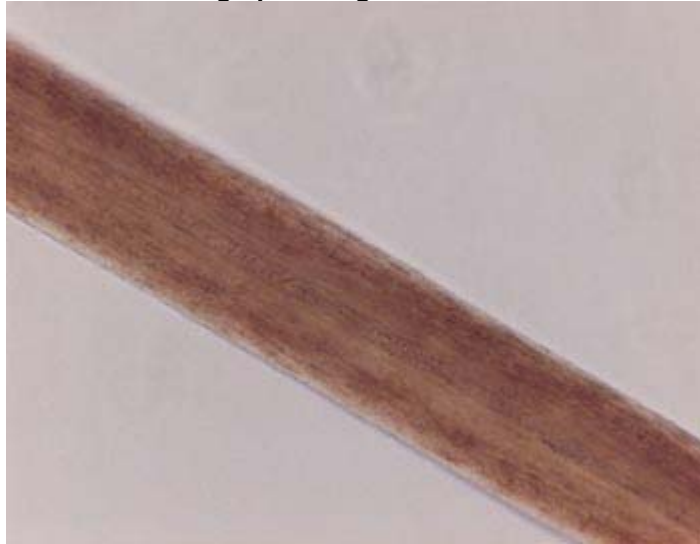


Figure 17. Photomicrograph of Pigment Distribution in Red Human Hair

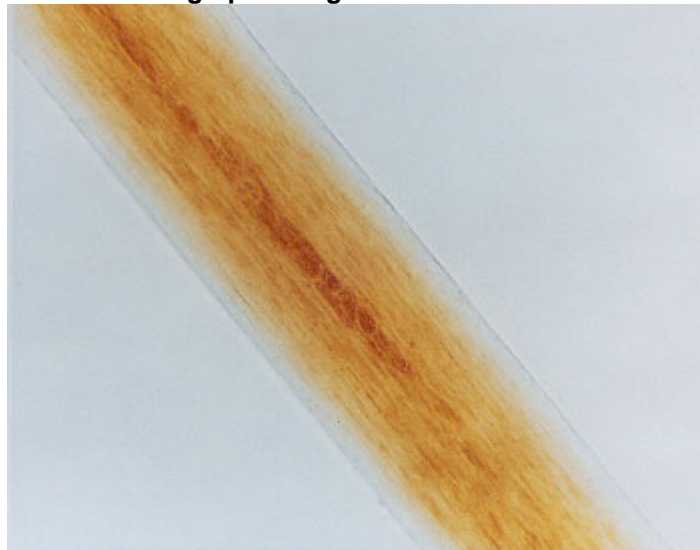


Figure 18. Photomicrograph of Pigment Distribution in Animal Hair



Ovoid bodies are large (larger than pigment granules), solid structures that are spherical to oval in shape, with very regular margins. They are abundant in some cattle (Figure 19) and dog (Figure 20) hairs as well as in other animal hairs. To varying degrees, they are also found in human hairs (Figure 21).

Figure 19. Photomicrograph of Ovoid Bodies in Cattle Hair



Figure 20. Photomicrograph of Ovoid Bodies in Dog Hair



Figure 21. Photomicrograph of Ovoid Bodies in Human Hair



Hair Identification

Animal Versus Human Hairs

Human hairs are distinguishable from hairs of other mammals. Animal hairs are classified into the following three basic types.

- Guard hairs that form the outer coat of an animal and provide protection
- Fur or wool hairs that form the inner coat of an animal and provide insulation
- Tactile hairs (whiskers) that are found on the head of animals provide sensory functions

Other types of hairs found on animals include tail hair and mane hair (horse). Human hair is not so differentiated and might be described as a modified combination of the characteristics of guard hairs and fur hairs.

Human hairs are generally consistent in color and pigmentation throughout the length of the hair shaft, whereas animal hairs may exhibit radical color changes in a short distance, called banding. The distribution and density of pigment in animal hairs can also be identifiable features. The pigmentation of human hairs is evenly distributed, or slightly more dense toward the cuticle, whereas the pigmentation of animal hairs is more centrally distributed, although more dense toward the medulla.

The medulla, when present in human hairs, is amorphous in appearance, and the width is generally less than one-third the overall diameter of the hair shaft. The medulla in animal hairs is normally continuous and structured and generally occupies an area of greater than one-third the overall diameter of the hair shaft.

The root of human hairs is commonly club-shaped (figure 22), whereas the roots of animal hairs are highly variable.

Figure 22. Photomicrograph of Human Hair Root



The scale pattern of the cuticle in human hairs is routinely imbricate. Animal hairs exhibit more variable scale patterns. The shape of the hair shaft is also more variable in animal hairs.

Human Hair Classifications

Hair evidence examined under a microscope provides investigators with valuable information.

Hairs found on a knife or club may support a murder and/or assault weapon claim. A questioned hair specimen can be compared microscopically with hairs from a known individual, when the characteristics are compared side-by-side.

Human hairs can be classified by racial origin such as Caucasian (European origin), Negroid (African origin), and Mongoloid (Asian origin). In some instances, the racial characteristics exhibited are not clearly defined, indicating the hair may be of mixed-racial origin.

The region of the body where a hair originated can be determined with considerable accuracy by its gross appearance and microscopic characteristics. The length and color can be determined. It can also be determined whether the hair was forcibly removed, damaged by burning or crushing, or artificially treated by dyeing or bleaching.

The characteristics and their variations allow an experienced examiner to distinguish between hairs from different individuals. Hair examinations and comparisons, with the aid of a comparison microscope, can be valuable in an investigation of a crime.

DNA Examinations

Hairs that have been matched or associated through a microscopic examination should also be examined by mtDNA sequencing. Although it is uncommon to find hairs from two different individuals exhibiting the same microscopic characteristics, it can occur. For this reason, the hairs or portions of the hairs should be forwarded for mtDNA sequencing. The combined procedures add credibility to each.

Although nuclear DNA analysis of hairs may provide an identity match, the microscopic examination should not be disregarded. The time and costs associated with DNA analyses warrant a preliminary microscopic examination. Often it is not possible to extract DNA fully, or there is not enough tissue present to conduct an examination. Hairs with large roots and tissue are promising sources of nuclear DNA. However, DNA examinations destroy hairs, eliminating the possibility of further microscopic examination.

Document reference: <http://www.fbi.gov>