

Module 4D

Forensic Examination of Hair

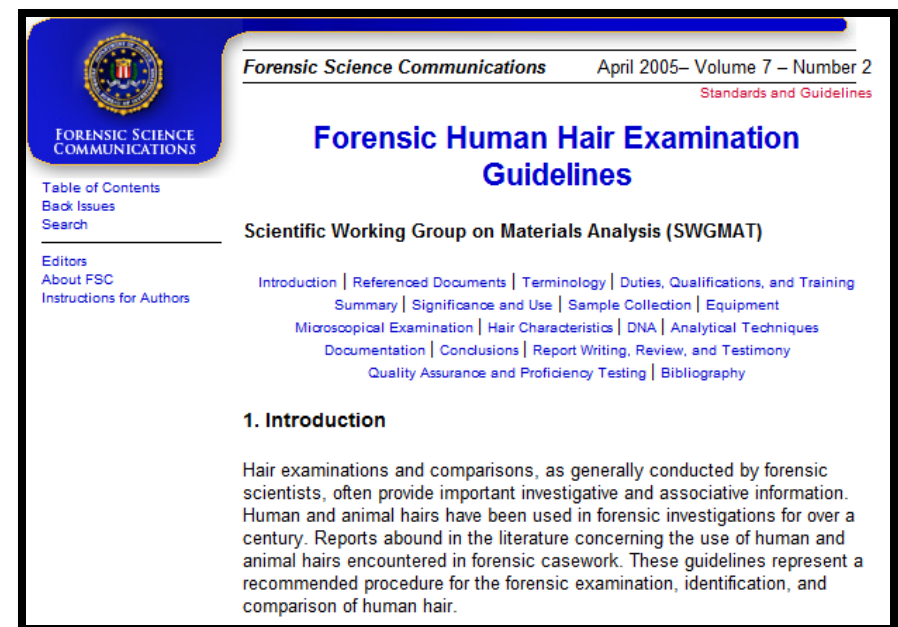
Forensic Science Teacher Professional Development

Part 4 Forensic Examination of Hair

Forensic examination of hair evidence can be split into two categories: human hairs and animal hairs. For human hair examination, see a guideline developed by the Scientific Working Group on Materials Analysis (SWGMAT).

Review the following link:

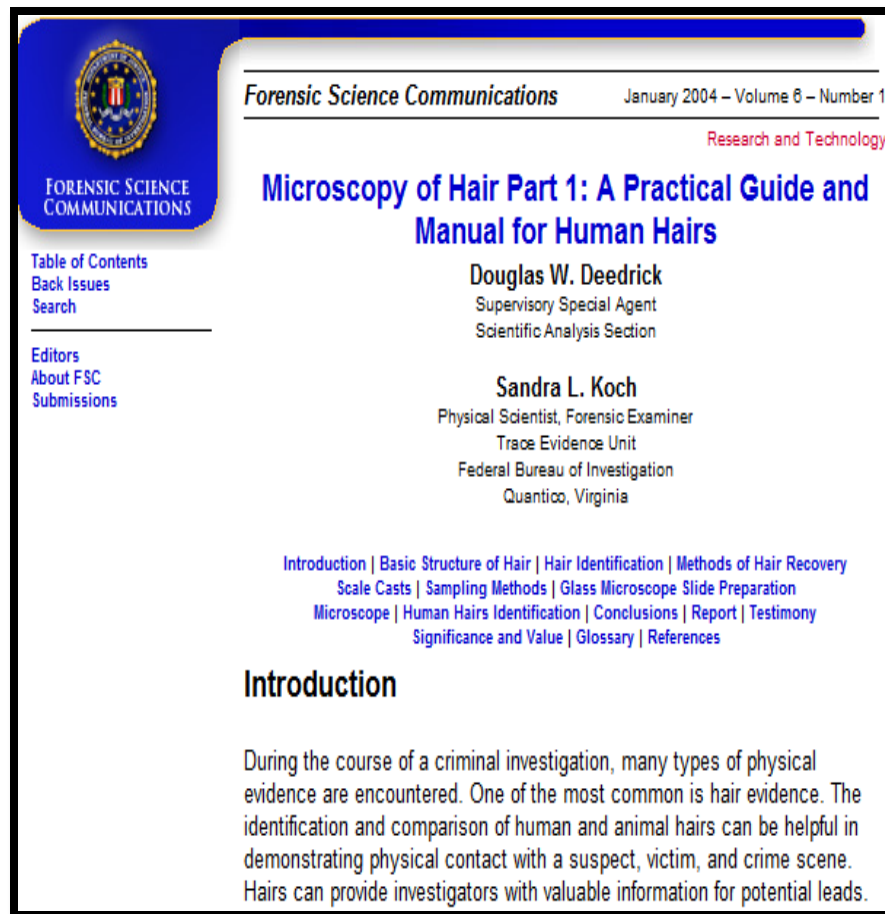
1. Forensic Human Hair Examination Guidelines



Part 4 Forensic Examination of Hair

Review the following link:

2. Microscopy of Hair Part I: A Practical Guide and Manual for Human Hairs



FORENSIC SCIENCE COMMUNICATIONS

Table of Contents
Back Issues
Search

Editors
About FSC
Submissions

Forensic Science Communications January 2004 – Volume 6 – Number 1
Research and Technology

Microscopy of Hair Part 1: A Practical Guide and Manual for Human Hairs

Douglas W. Deedrick
Supervisory Special Agent
Scientific Analysis Section

Sandra L. Koch
Physical Scientist, Forensic Examiner
Trace Evidence Unit
Federal Bureau of Investigation
Quantico, Virginia

Introduction | Basic Structure of Hair | Hair Identification | Methods of Hair Recovery
Scale Casts | Sampling Methods | Glass Microscope Slide Preparation
Microscope | Human Hairs Identification | Conclusions | Report | Testimony
Significance and Value | Glossary | References

Introduction

During the course of a criminal investigation, many types of physical evidence are encountered. One of the most common is hair evidence. The identification and comparison of human and animal hairs can be helpful in demonstrating physical contact with a suspect, victim, and crime scene. Hairs can provide investigators with valuable information for potential leads.

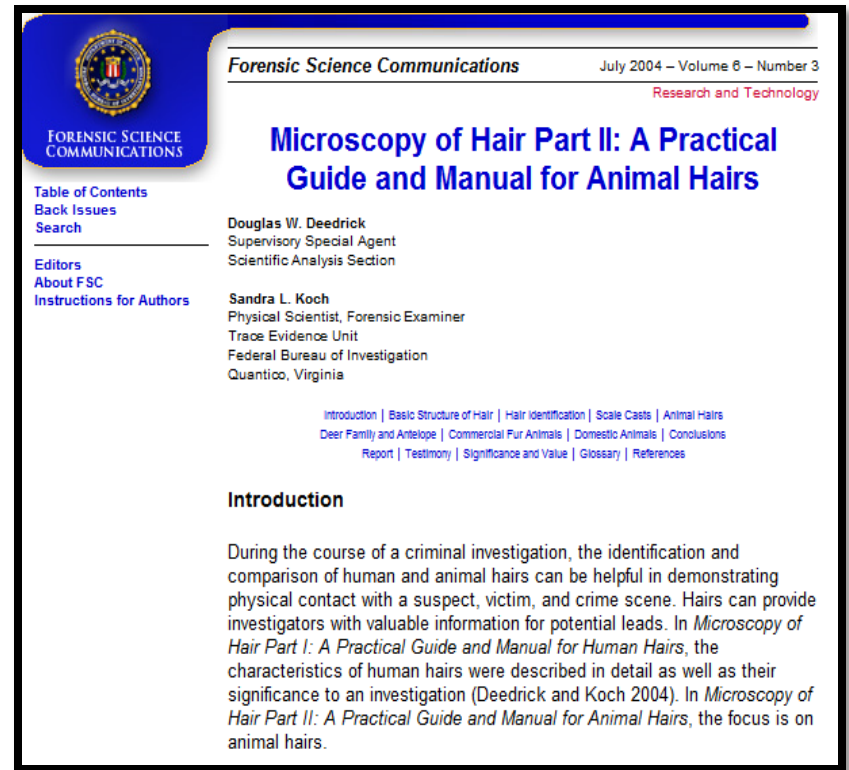
http://www.fbi.gov/about-us/lab/forensic-science-communications/fsc/jan2004/research/2004_01_research01b.htm

Note that an examination of human hair may reveal the possible racial origin and the somatic origin. It is not yet possible to individualize a human hair to any single head or body through its morphology.

Part 4 Forensic Examination of Hair

Review the following link:

3. Microscopy of Hair Part II: A Practical Guide and Manual for Animal Hairs



The image shows the cover of the journal 'Forensic Science Communications'. The cover is white with a blue header and footer. The title 'Microscopy of Hair Part II: A Practical Guide and Manual for Animal Hairs' is prominently displayed in blue. The authors, Douglas W. Deedrick and Sandra L. Koch, are listed below the title. The journal's logo is in the top left corner, and the issue information (July 2004, Volume 6, Number 3) is in the top right. A navigation menu is on the left side, and a list of contents is at the bottom.

FORENSIC SCIENCE COMMUNICATIONS

Forensic Science Communications July 2004 – Volume 6 – Number 3
Research and Technology

Microscopy of Hair Part II: A Practical Guide and Manual for Animal Hairs

Douglas W. Deedrick
Supervisory Special Agent
Scientific Analysis Section

Sandra L. Koch
Physical Scientist, Forensic Examiner
Trace Evidence Unit
Federal Bureau of Investigation
Quantico, Virginia

[Introduction](#) | [Basic Structure of Hair](#) | [Hair Identification](#) | [Scale Casts](#) | [Animal Hairs](#)
[Deer Family and Antelope](#) | [Commercial Fur Animals](#) | [Domestic Animals](#) | [Conclusions Report](#) | [Testimony](#) | [Significance and Value](#) | [Glossary](#) | [References](#)

Introduction

During the course of a criminal investigation, the identification and comparison of human and animal hairs can be helpful in demonstrating physical contact with a suspect, victim, and crime scene. Hairs can provide investigators with valuable information for potential leads. In *Microscopy of Hair Part I: A Practical Guide and Manual for Human Hairs*, the characteristics of human hairs were described in detail as well as their significance to an investigation (Deedrick and Koch 2004). In *Microscopy of Hair Part II: A Practical Guide and Manual for Animal Hairs*, the focus is on animal hairs.

http://www.fbi.gov/about-us/lab/forensic-science-communications/fsc/july2004/research/2004_03_research02.htm

Part 4 Forensic Examination of Hair

Review the following link:

4. An on-line animal fur database

<http://alaskafurid.wordpress.com/about/>



[Alaska Fur ID Project](#)

[INDEX](#) [BIBLIO](#) [GLOSSARY](#) [SAMPLING](#)

Pages

- [INDEX](#)
- [BIBLIO](#)
- [GLOSSARY](#)
- [SAMPLING](#)

Categories

- [Uncategorized](#)

INDEX

- [Bear, Black](#)
- [Bear, Brown](#)
- [Bear, Polar](#)
- [BEARS](#)



Part 4 Forensic Examination of Hair

Highlights from the FBI hair examination guidelines

Stereomicroscope Examination of Hair Evidence

- Hair characteristics, such as color, length, shape, and texture, first can be examined by the use of a stereomicroscope.
- The purpose of this step is to identify hairs and assess which are suitable for further comparisons.
- Within this step, the presence of other trace materials and microscopic patterns associated with the hair samples can be noted.
- Hair roots can also be screened in this step to identify those hairs suitable for nuclear DNA analysis.

Part 4 Forensic Examination of Hair

Highlights from the FBI hair examination guidelines

Compound Light Microscope Examination of Hair Evidence

Human hair grows from hair follicles deep in the dermis. It is a filamentous outgrowth of protein projecting from the epidermis.

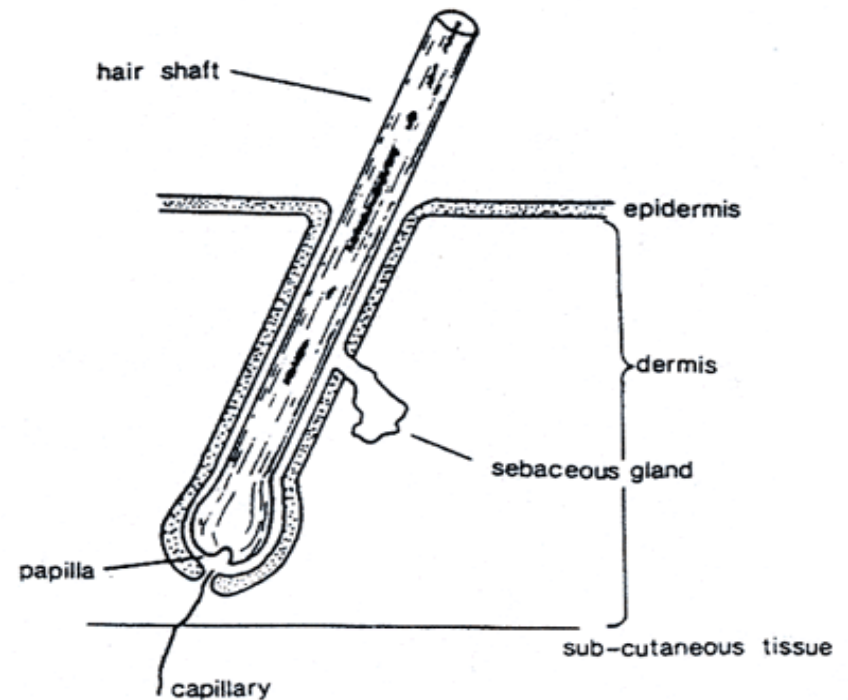


Figure 11

The outgrowth of hair from a hair follicle



Part 4 Forensic Examination of Hair

Highlights from the FBI hair examination guidelines

- The term “hair” can also be used to indicate other filamentous fibers found on the skin of animals and sometimes in plants.
- The hair of non-human mammal species is commonly referred to as fur. There are some cats, dogs, and mice bred to have little or no visible fur.
- In some species, hair is not present at certain stages of life. Although many other organisms, especially insects, show filamentous outgrowths, these structures are not considered hair.
- Trichomes, filamentous outgrowths on plants, are sometimes called “hairs.”

Part 4 Forensic Examination of Hair

Highlights from the FBI hair examination guidelines

- Human hair follicles grow in repeated cycles. One cycle can be broken down into three phases:
 - **Anagen – growth phase**
 - **Catagen - transitional phase**
 - **Telogen – resting phase**
- Each hair grows through the phases independent of the neighboring hairs.
- The distinction is important for DNA examination. For example, nuclear DNA can only be discovered in hairs that are in the anagen phase.



Part 4 Forensic Examination of Hair

Highlights from the FBI hair examination guidelines

- Human beings have about 1.4 million hairs on their bodies and about 450,000 of them are found above the neck. These hairs include about 100,000 hairs on the head and about 30,000 hairs on the face, such as mustaches or beards.
- The following shows the average growth rate per day:
 - Hairs on the head: 0.35mm
 - Eyebrows: 0.15mm
 - Mustaches: 0.4mm
 - Armpit hairs: 0.3mm
 - Pubic hairs: 0.2mm



Part 4 Forensic Examination of Hair

Highlights from the FBI hair examination guidelines

- The major component of human hair is keratin, which is a member of the fibrous structural proteins family.
- There are various types of keratins within a single animal.
- The α -keratins can be found in the hair, horns, nails, claws, and hooves of mammals, and the harder β -keratins can be found in the scales and claws of reptiles.

Part 4 Forensic Examination of Hair

Highlights from the FBI hair examination guidelines

- For microscopic examination of hair, a colorless mounting medium with a refractive index (RI) in the range of 1.50 to 1.60 should be used in order to view microscopic morphological features of hairs under transmitted light mode.
- The Cargille Meltmount™ 1.539 (RI=1.539), and Permunt (RI=1.54) are commonly used. The Cargille Meltmount™ series of mounting media are specially formulated thermoplastics for use in microscope slide mounting.

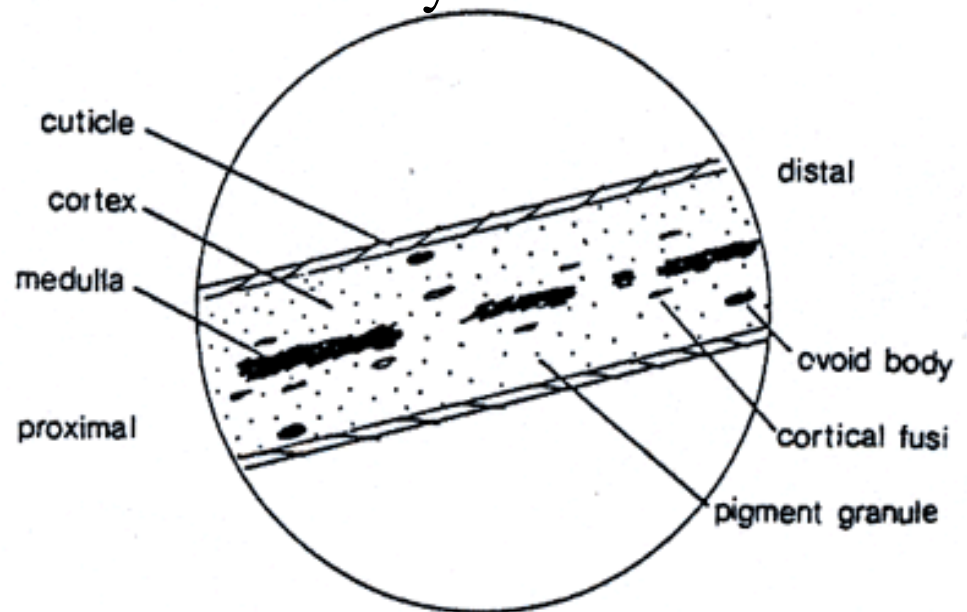
Note that Meltmount 1.539 has a RI of 1.539 and an Abbe V dispersion (this is a measure of dispersion for visible light) of 45, making it optically similar to Canada Balsam. Therefore, Meltmount can be ideal for mounting many biological specimens for both optical performance and sample preservation purposes. More details can be found at <http://www.cargille.com/meltmount.shtml> .

Part 4 Forensic Examination of Hair

Highlights from the FBI hair examination guidelines

- With the use of a mounting medium for hair samples, microscopic morphology of hair, such as cuticle, medulla, and cortex, can be observed successfully.

Figure 12 Microscopic morphological features of hair





Part 4 Forensic Examination of Hair

Highlights from the FBI hair examination guidelines

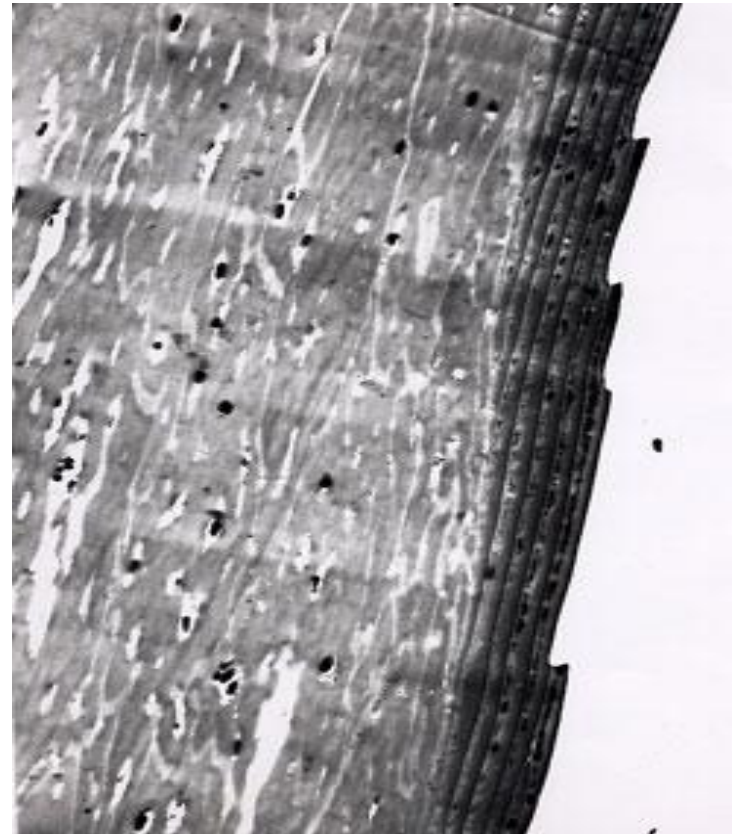
- The cortex part of hair is an amorphous, unorganized protein matrix of high sulfur content.
- The packed dead cells surrounding the cortex structures are known as the cuticular layers (cuticle) of the hair.
- In the center of the hair lies the medullary canal (medulla), which is actually a part of the excretory system and houses many foreign debris, heavy metals, synthetics, and medications that might be thrown off by the body and released through this medullary canal.
- It is not uncommon for medulla to be absent in human hairs.

Part 4 Forensic Examination of Hair

Highlights from the FBI hair examination guidelines

Cuticle

Figure 13 The cuticle is a translucent outer layer of the hair shaft consisting of scales that cover the shaft. The scales always point from the proximal (or root end of the hair) to the distal (or tip end of the hair).





Part 4 Forensic Examination of Hair

Highlights from the FBI hair examination guidelines

There are three basic scale patterns of the cuticle:

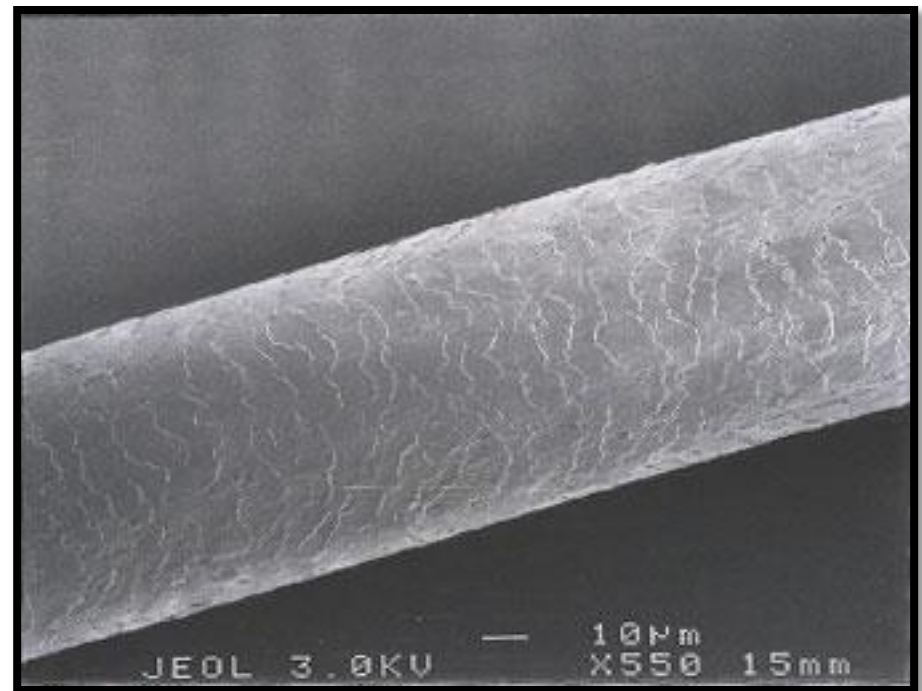
- 1) **Coronal (crown-like):** The coronal, or crown-like scale pattern is found in hairs of very fine diameter and is like a stack of paper cups. Coronal scale patterns are commonly found in the hairs of small rodents and bats but rarely in human hairs.
- 2) **Spinous (petal-like):** These cuticles 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.
- 3) **Imbricate (flattened):** This type of scale pattern consists of overlapping scales with narrow margins. They are commonly found in human hairs and many animal hairs.

Part 4 Forensic Examination of Hair

Highlights from the FBI hair examination guidelines

Hair scale patterns are best observed by the use of a scanning electron microscope (SEM).

Figure 14 Hair scale pattern observed by a SEM

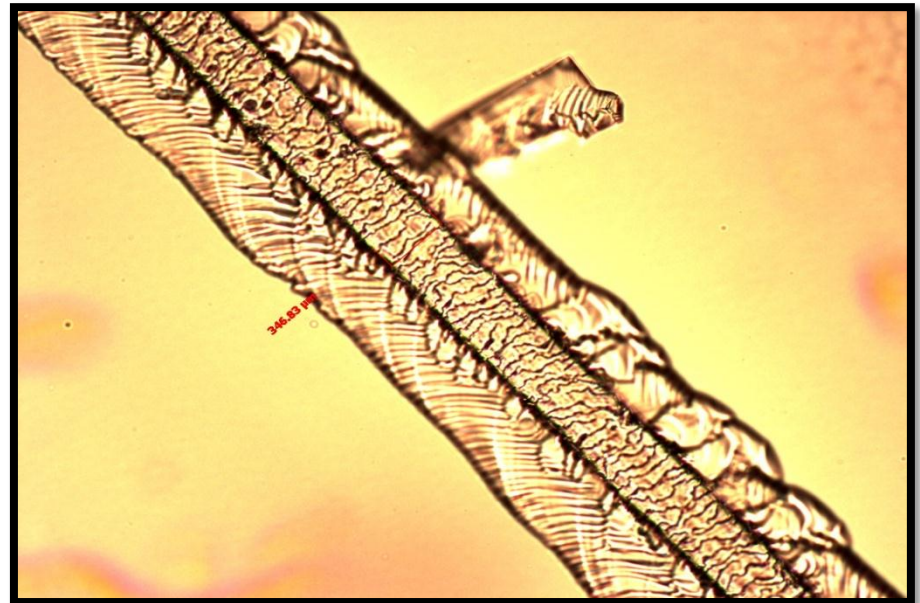


Part 4 Forensic Examination of Hair

Highlights from the FBI hair examination guidelines

- An alternative way to examine scale patterns of hair is to produce a cast of the hair. Imprints of scale pattern can be casted by using a nail polish. The hair scale pattern imprinted on a dry thin layer of nail polish can then be observed by a compound light microscope under transmittance mode.

Figure 15 An imprint of imbricate scale pattern on a thin layer of dried nail polish observed by a compound light microscope under transmittance mode





Part 4 Forensic Examination of Hair

Highlights from the FBI hair examination guidelines

- To prepare a scale cast, a nail polish can be first applied on a clean microscope slide.
- While the nail polish is still wet, a hair can be positioned on top of the nail polish on the slide.
- Let the nail polish dry completely, then gently remove the hair to obtain a scale imprint.

Part 4 Forensic Examination of Hair

Highlights from the FBI hair examination guidelines

Medulla:

The medulla is a central core of cells that may be present in a hair sample. If this region is filled with air, the microscopic structure of medulla appears as a black or opaque structure under transmitted light. If this region is filled with mounting medium or some other clear substance, the structure appears clear or translucent in transmitted light. In human hairs, the medulla is generally amorphous in appearance. In animal hairs, the medulla pattern is frequently structured and well-defined.

Figure 16 Microscopic pattern of cellular medulla observed under transmittance mode (mounting medium: Permunt)

The dark region is the area filled with air. The transparent region is the area filled with liquid or mounting medium.



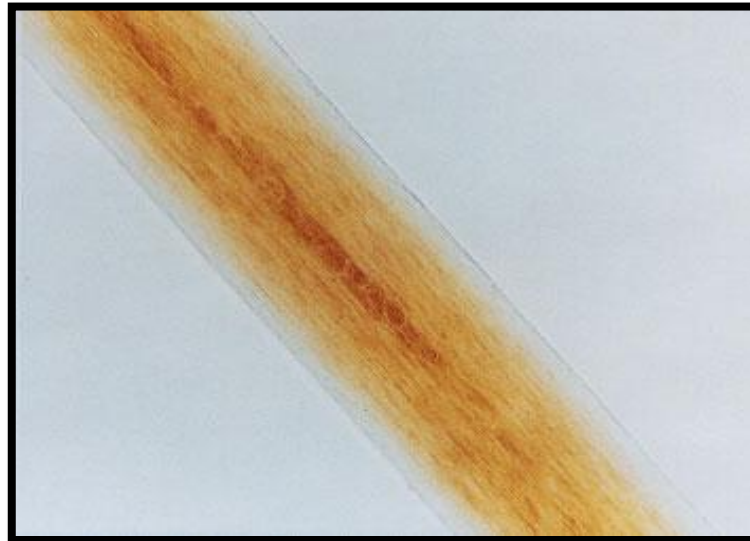
Part 4 Forensic Examination of Hair

Highlights from the FBI hair examination guidelines

Cortex:

The cortex is the main body of the hair composed of elongated cells. Detailed structures within this region may contain cortical fusi, pigment granules, and ovoid bodies. Pigment granules are small, dark, and solid structures that are granular in appearance. They may vary in color, size, and distribution in a single hair.

Figure 17
Pigment
distribution in
red human hair



Part 4 Forensic Examination of Hair

Highlights from the FBI hair examination guidelines

Ovoid bodies are large (larger than pigment granules), solid structures that are spherical to oval in shape, with very regular margins. They are commonly found in Negroid human hairs and cattle hairs.

Figure 18 Ovoid bodies in a cattle hair





Part 4 Forensic Examination of Hair

Highlights from the FBI hair examination guidelines

Animal hairs are classified into the following three basic types:

- 1) Guard hairs: the outer coat of an animal that provides protection
- 2) Fur or wool hairs: the inner coat of an animal that provides insulation
- 3) Tactile hairs (whiskers): found on the head of animals to provide sensory functions



Part 4 Forensic Examination of Hair

Highlights from the FBI hair examination guidelines

Comparison Between Human and Non-human (Animal) Hairs

Human hair can be distinguished from non-human hair by examining features, such as scale pattern, medulla, root, color, hair length, and shaft configurations.

- Human hairs are generally consistent in color and pigmentation throughout the hair shaft, whereas non-human hairs may have radical color changes in a short distance (called banding).



Part 4 Forensic Examination of Hair

Highlights from the FBI hair examination guidelines

Comparison Between Human and Non-human (Animal) Hairs, continued

- The density of pigment in human hairs can be evenly distributed, or slightly denser toward the cuticle, whereas the pigmentation of non-human hairs is more centrally distributed 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 non-human hairs is normally continuous and structured. Medulla structure in non-human hairs generally occupies an area of greater than one-third the overall diameter of the hair shaft.



Part 4 Forensic Examination of Hair

Highlights from the FBI hair examination guidelines

Comparison Between Human and Non-human (Animal) Hairs, continued

- The root of human hairs is commonly club-shaped, whereas the roots of non-human hairs are highly variable.
- The scale pattern of the cuticle in human hairs is routinely imbricate. Non-human hairs exhibit more variable scale patterns. The shape of the hair shaft is also more variable in non-human hairs.



Part 4 Forensic Examination of Hair

Highlights from the FBI hair examination guidelines

Somatic Origin of Human Hair

- Somatic origin types may include scalp, pubic, facial, limb, and body. Somatic origin of human hair can usually be established by considering features such as length, cross-sectional shape, shaft configuration, medulla pattern, texture, and appearance of the root.



Part 4 Forensic Examination of Hair

Highlights from the FBI hair examination guidelines

A Summary of Characteristics of Microscopic Human Hair Morphology

1. Shaft characteristics

- Diameter range: fine, moderate, or coarse
- Cross-sectional shape: round, oval, flattened
- Shaft configurations: buckling, convoluting, shouldering, undulating, splitting, regular



Part 4 Forensic Examination of Hair

Highlights from the FBI hair examination guidelines

A Summary of Characteristics of Microscopic Human Hair Morphology

2. Medulla characteristics

- Absent
- Continuous
- Discontinuous
- Fragmented
- Opaque
- Translucent
- Relative width
- Amorphous
- Other (e.g., doubled, tripled)



Part 4 Forensic Examination of Hair

Highlights from the FBI hair examination guidelines

A Summary of Characteristics of Microscopic Human Hair Morphology

3. Cuticle characteristics

- Cuticle: present, absent
- Cuticle thickness: thin, medium, thick
- Outer cuticle margin: flattened, smooth serrated, cracked, looped, irregular, or other
- Inner cuticle margin: distinct, indistinct
- Cuticle color and clarity: natural, pigment, dye



Part 4 Forensic Examination of Hair

Highlights from the FBI hair examination guidelines

A Summary of Characteristics of Microscopic Human Hair Morphology

4. Cortex characteristics

- Cellular texture: coarse, medium, fine
- Ovoid bodies: size, distribution, abundance
- Cortical fusi : size, shape, distribution, abundance



Part 4 Forensic Examination of Hair

Highlights from the FBI hair examination guidelines

Characteristics of ends

1. Proximal ends

- Root present: telogen, catagen, anagen, sheathed, follicular tag, postmortem banding, putrid
- Root absent: severed, decomposed, crushed

2. Distal ends

- Tapered tips (uncut), rounded or abraded, square cut, angular cut, frayed, split, crushed, broken, singed



Part 4 Forensic Examination of Hair

Conclusions of Human Hair Examination

1. Many factors may strengthen or weaken a conclusion of hair examination. The magnitude and significance of any factor can determine what conclusion can be formed. The hair examiner should consider what meaning could be attached to an exclusion or non-exclusion based on the case circumstances.
2. Probabilities and population statistics should not be used to interpret microscopic hair comparisons. Databases from which population statistics can be generated, as in DNA analysis, are not practical or realistic in microscopic examination of hair morphology. An explanation follows.



Part 4 Forensic Examination of Hair

Conclusions of Human Hair Examination

Explanation:

Basically, hair analysis is an “exclusion” test, not an “identification” test. It is useful when you exclude the suspect based on the evidence. When you use an identification test (like DNA analysis) and you discover a match between the evidence and the suspect, you need to report the strength of the match. You can do that because population studies were performed in different representative populations, and these population databases were statistically tested for forensic purposes.



Part 4 Forensic Examination of Hair

Conclusions of Human Hair Examination

3. The following conclusions may be reached as a result of a microscopic hair examination:
 - a) A sample can be identified as a human hair.
 - b) Known and questioned hairs are similar.
 - c) Inconclusive. Not enough morphological characteristics can be observed from the hair sample.



Part 4 Forensic Examination of Hair

Conclusions of Human Hair Examination

3. The following conclusions may be reached as a result of a microscopic hair examination:
 - d) Known and questioned hairs are dissimilar.
 - i. This conclusion may be strengthened when known and questioned hairs exhibit gross differences (e.g., racial, color, diameter, chemical treatment), adequate known samples are available, and known hair has little intrasample variation.
 - ii. This conclusion may be weakened when known and questioned hairs exhibit some similarities and no gross difference, inadequate known or questioned samples are available, and known hair has large intrasample variation.

End of Module 4D

Forensic Science Teacher Professional Development