

Unit 2: Hair and Fiber Evidence

Hair Analysis

By the end of this unit you will be able to:

- 1 Identify the various parts of a hair.
- 2 Describe variations in the structure of the medulla, cortex, and cuticle.
- 3 Distinguish between human and nonhuman animal hair.
- 4 Explain how hair can be used in a forensic investigation.
- 5 Calculate the medullary index for a hair.
- 6 Distinguish hairs from individuals belonging to broad racial categories.



Vocabulary

- ▶ comparison microscope
- ▶ cortex
- ▶ cuticle
- ▶ gas chromatography
- ▶ hair follicle

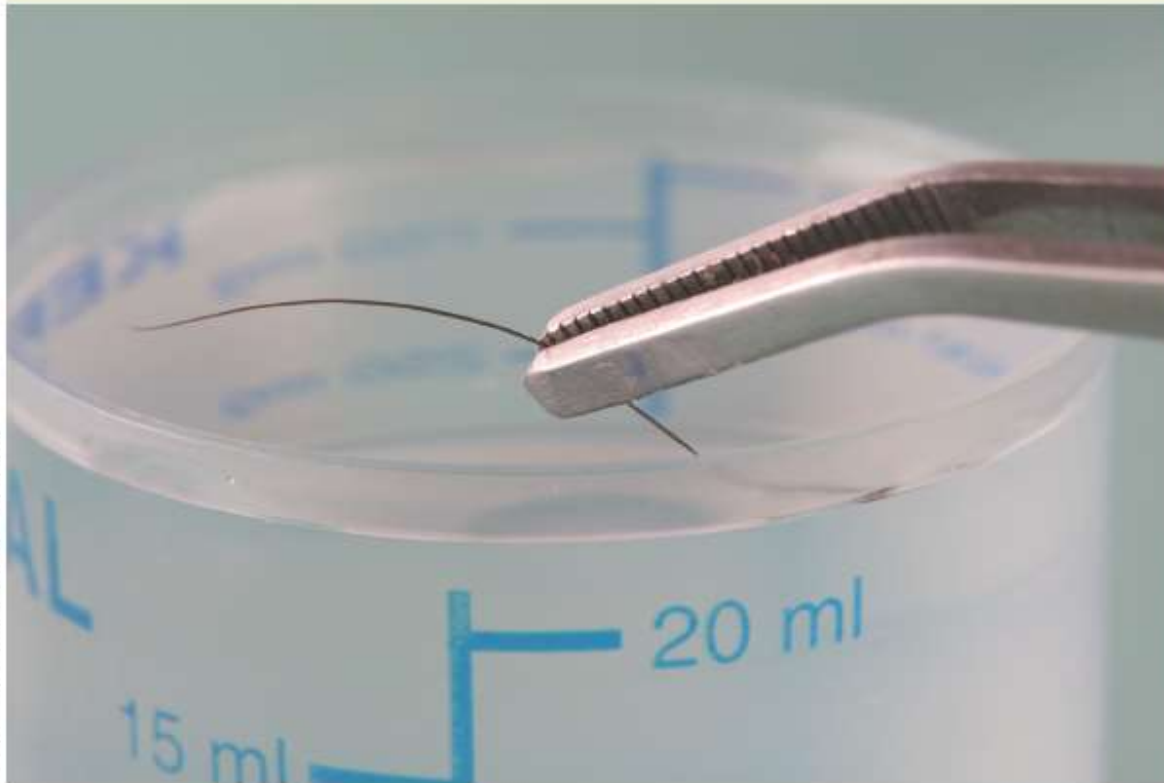
- hair shaft
- keratin
- medulla
- melanin granules
- mitochondrial DNA (mtDNA)
- nuclear DNA

Introduction



- Hair can yield class evidence.
- A hair without the follicle and its nuclear DNA cannot provide individual evidence.
- Chemical tests performed on hair can reveal drugs, toxins, heavy metals and nutritional deficiencies.
- Mitochondrial DNA (mtDNA) from hair can reveal some of a suspect's or victim's family relationships.

Figure 3-1 *A forensic scientist prepares a hair for analysis.*



Ldf/Thinkstock/Getty Images

The Functions of Hair

- Regulates body temperature
 - “goosebumps” trap warm air under upright hair
- Decreases friction
- Protects against sunlight
- Acts as a sense organ
- Humans are born with about 5 million hair follicles.

The Structure of Human Hair

- o Human hair consists of a follicle and a shaft.

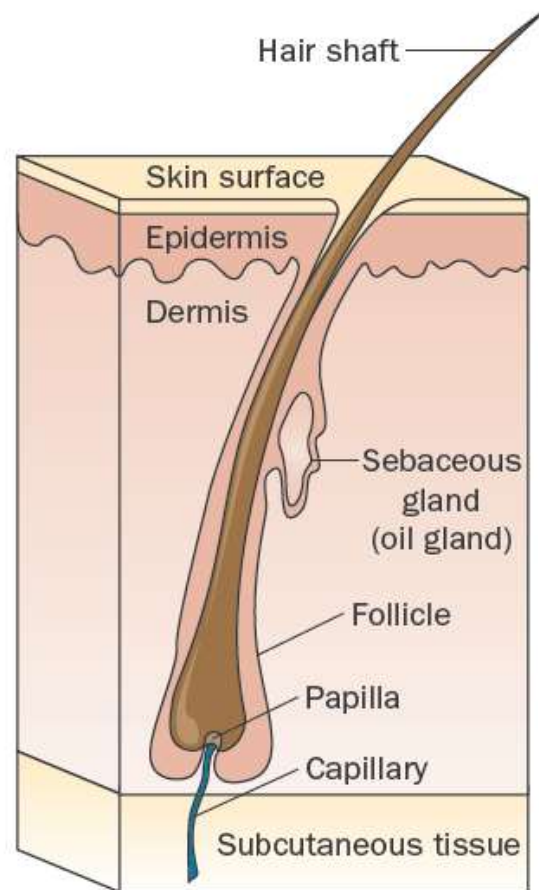


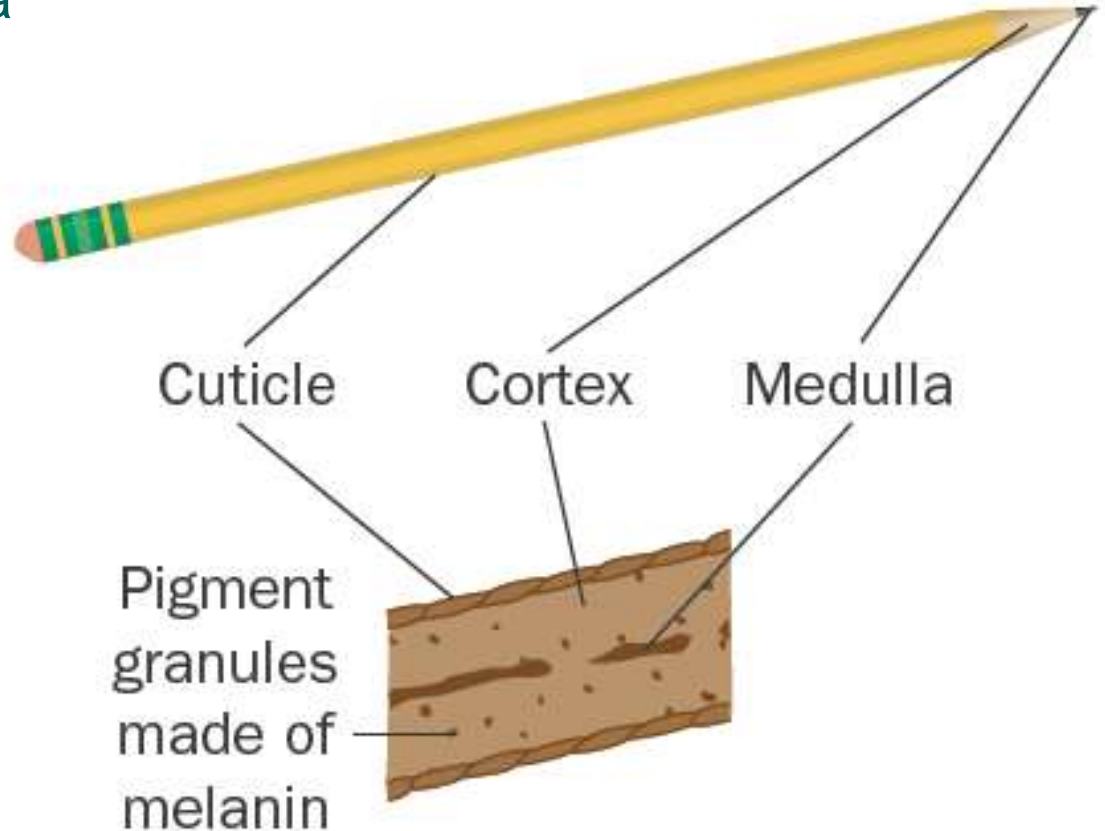
Figure 3-2 This cross section shows a hair shaft in a hair follicle. If the follicle of the hair is present in evidence, nuclear DNA may be extracted, amplified, and analyzed for use as individual evidence. If no follicle is present, mitochondrial DNA or other characteristics may be analyzed for use as class evidence for comparison with crime-scene evidence.

The Structure of Human Hair

(continued)

- The hair shaft is made up of three layers:
 - An inner medulla
 - A cortex
 - An outer cuticle

Figure 3-3 *The cross section of a hair shaft is similar to that of a round, wooden pencil.*



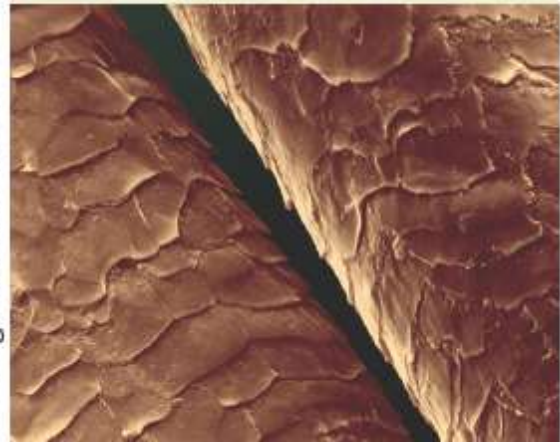
The Structure of Human Hair

(continued)

- The cuticle is a transparent outer layer of the hair shaft.
 - Have different shapes/patterns depending on species of mammal
 - Scales point from scalp to end, which helps determine younger and older hair

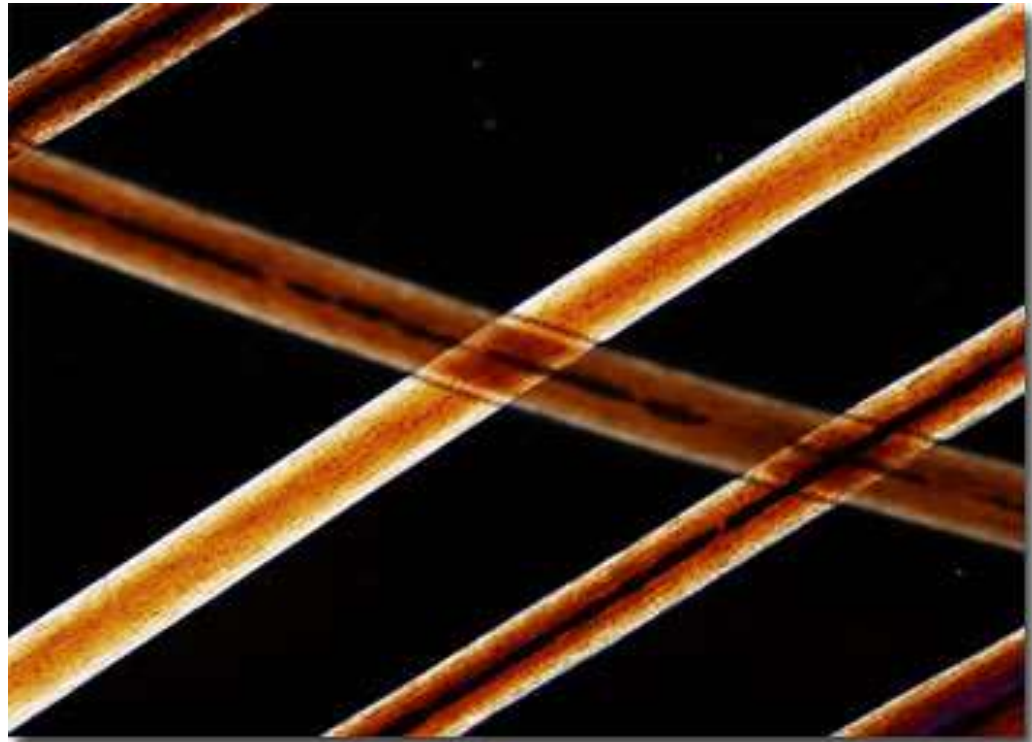
Figure 3-4 This scanning electron photomicrograph shows the cuticle of a human hair with the overlapping (imbricate) scales.

Dee Bregger/Science Source








o Cortex:

- **Thickest layer**
- Contains most of the pigment
- Distribution of **pigment** varies
- Usually denser nearer the cuticle



Types of Medulla

Figure 3-5 Five different patterns of medulla pigmentation pattern are identified in forensic hair analysis.

Medulla Pattern	Description	Diagram
Continuous	One unbroken line of color	
Interrupted (intermittent)	Pigmented line broken at regular intervals	
Fragmented or Segmented	Pigmented line unevenly spaced	
Solid	Pigmented area filling both the medulla and the cortex	
None	No separate pigmentation in the medulla	

Types of Hair

- In humans, hair varies from person to person, and even varies depending on its location on a particular person.
- For an individual person, hair can vary based on its location on the body.
- To compensate for inconsistencies that occur, 50 hairs are usually collected from a suspect's or victim's head.

Types of Hair

- Hair can vary in:
 - Shape
 - Length
 - Diameter
 - Texture
 - Color

Hair from Different Parts of the Body

Human hair varies on the body

1. Head Hair
2. Eyebrows and Eyelashes
3. Beard and Mustache Hair
4. Underarm Hair
5. Body hair (Auxiliary Hair)
6. Pubic Hair

Hair from Different Parts of the Body

Figure 3-7 *The physical characteristics of a hair provide information about which part of the body it came from.*



Pubic hair showing buckling.



Beard hair with double medulla.



Arm or leg hair with blunt, frayed end.

The Life Cycle of Hair

Hair proceeds through three stages as it develops.

- o Anagen stage: (80-90% of hair)
 - hair actively grows
 - cells around the follicle rapidly divide and deposit materials in the hair
 - Lasts approximately 1000 days

The Life Cycle of Hair

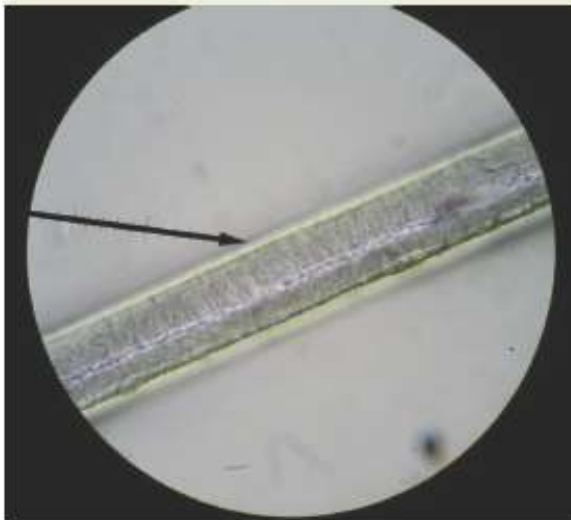
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- Catagen stage: (2% of hair)
 - The hair stops growing
 - Follicle recedes
 - Can change / turn grey
- Telogen stage: (10 – 18% of hair)
 - Follicle becomes dormant
 - Hairs are easily lost

Treated Hair

- Hair can be treated in many different ways
 - Dyed, bleached, relaxed
 - Chemicals remain
 - Changes can be detected by microscope

Figure 3-8 *Bleached hair lacks pigment in the cortex and cuticle.*



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Figure 3-9 *Examples of dyed human hair. Notice the dye stains the entire hair, including the cuticle and cortex.*










FBI; photos by Sandra Koch & Douglas W. Deedric

Ethnic or Ancestral Differences

- There are some key physical characteristics that are associated with hair of different ancestral groups.

Figure 3-10 A comparison of general characteristics of hair from people of different ancestries.

Ancestry	Appearance	Pigment Granules	Cross Section	Other
European	Generally straight or wavy 	Small and evenly distributed	Oval or round of moderate diameter with minimal variation 	Color may be blond, red, brown, or black
Asian	Straight 	Densely distributed	Round with large diameter 	Shaft tends to be coarse and straight; thick cuticle; continuous medulla; color black
African	Kinky, curly, or coiled; shaft may be buckled 	Densely distributed, clumped, may differ in size and shape	Flattened with moderate to small diameter and considerable variation 	

Courtesy, FBI; photos by Sandra Koch & Douglas W. Deedrick

Racial Differences



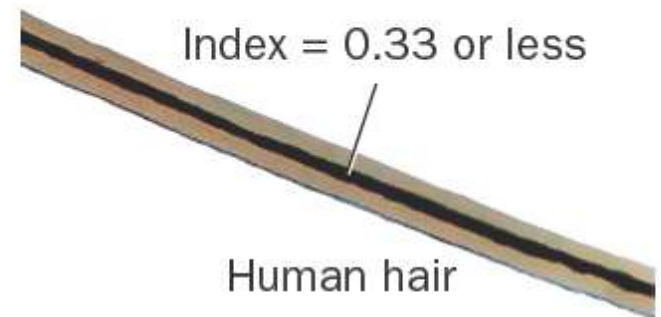
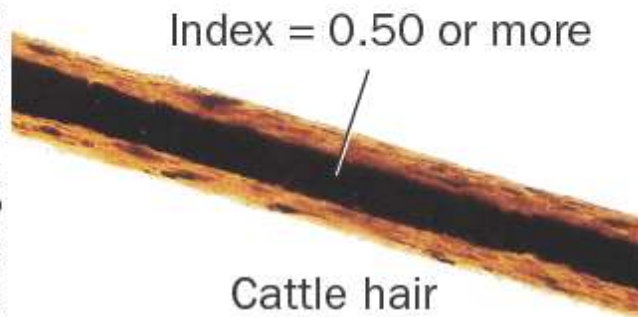
- Broad racial categorization can be made by identifying certain characteristics of hair.
- These characteristics may NOT be applicable to all individuals in these groups.
- Therefore, Individual hairs CANNOT be assigned to any of these groups

Animal hair and Human Hair

- o Animal hair and human hair have several differences including:
 - The pattern of pigmentation
 - 📖 Animal hair is denser toward the medulla, humans toward the cuticle
 - 📖 Animals can have banded patterns, humans can't
 - The medullary index
 - The cuticle type

Figure 3-11 *The medulla of animal hair is proportionally much thicker than in human hair, and it is always continuous.*

Courtesy, FBI; photos by Sandra Koch & Douglas W. Deedrick



Hair Cuticles

- o The cuticle of the hair shaft can help distinguish human hair from other animal hair.

Figure 3-12 *Imbricate (human), coronal (mouse), and spinous (cat) cuticles.*

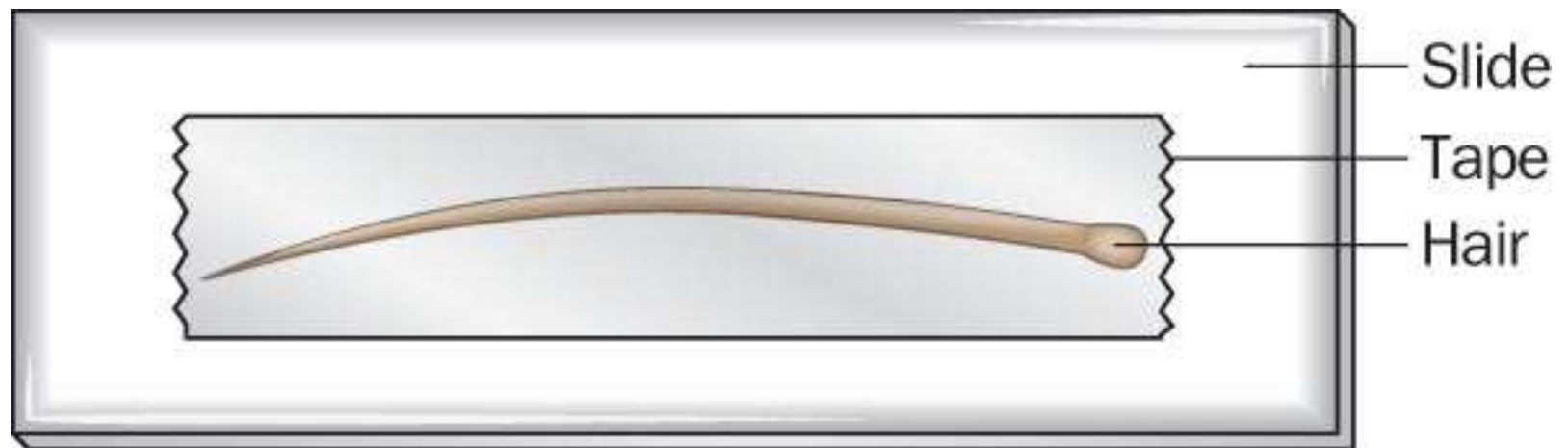


Using Hair in an Investigation

- Investigators often make observations about the macroscopic and microscopic features of a hair
 - Microscopes (especially comparison microscopes) are important tools
 - 📁 Morphological characteristics
 - 📁 Matching color, length, diameter, medulla
 - Different microscopes provide different kinds of evidence.

Microscopic Assessment

- Preparation



Electron Microscopes

- Direct a beam of electrons at a sample.
- Provide magnification of 50,000 times or more.

Figure 3-14 A transmission electron microscope produced this extremely detailed image of a long section of human hair. Notice the overlapping cuticle scales on the left side and the pigment granules in the cortex.

Courtesy, FBI; photos by Sandra Koch & Douglas W. Deedrick



Testing for Substances in the Hair Shaft

- Some toxins and drugs which an individual has ingested leave traces in the hair.
- Chemical tests determine presence of various substances
 - Can calculate the length of time during which a person was taking drugs or ingesting other toxins.

Collection and Preservation

- As a general rule, forensic hair comparisons involve either head hair or pubic hair.
- The collection of 50 full-length hairs from all areas of the scalp will normally ensure a representative sampling of head hair.
- A minimum collection of 24 full-length pubic hairs should cover the range of characteristics present in pubic hair.
- Hair samples are also collected from the victim of suspicious deaths during an autopsy.

Hair Examination and Testing

- DNA is extracted and amplified using PCR.
- DNA is profiled using an automated process.
- mtDNA can be used to establish a genetic relationship through the mother.
- Suspects can be excluded if their mtDNA is not consistent with the crime-scene mtDNA.

A young girl, Alma Tirtsche, was found strangled and bludgeoned to death in Melbourne, Australia, in 1922. Her naked body had been wrapped in a blanket and dumped in an alley. There was no blood found at the scene, prompting investigators to conclude that she had been killed in one place and then transported to the alley at a later time.

As the investigation progressed, Colin Ross became a suspect. Police searched his home and obtained two more blankets that they sent to Dr. Charles Taylor for analysis. On one he found strands of reddish-gold hair, the same color as Alma's. Dr. Taylor determined that the hairs were indeed human and that they were most likely female (they were more than 12 inches long). He also concluded that because the hair had so much pigmentation, it must be from a young person. Some of the hairs had roots, suggesting that they were pulled out during a violent encounter. The hair evidence indicating that Alma had been in contact with the blanket found at Ross's home was enough to convict him.

Colin Ross was found guilty of murder and hanged four months later.

More than eighty years later, in his book *Gun Alley: Murder, Falsehood, and Failure of Justice*, Kevin Morgan proved that Ross was most probably innocent. Largely because of Morgan's research, Colin Ross was exonerated and officially pardoned May 27, 2008.

Analysis

1. There are many cases over the years where someone was convicted on hair evidence, only to be exonerated later by DNA testing. Research and report on one of these cases.
2. Should a prosecutor, judge or jury be able to convict on hair evidence alone? Why or why not?



Source: FBI.gov



Source: FBI.gov