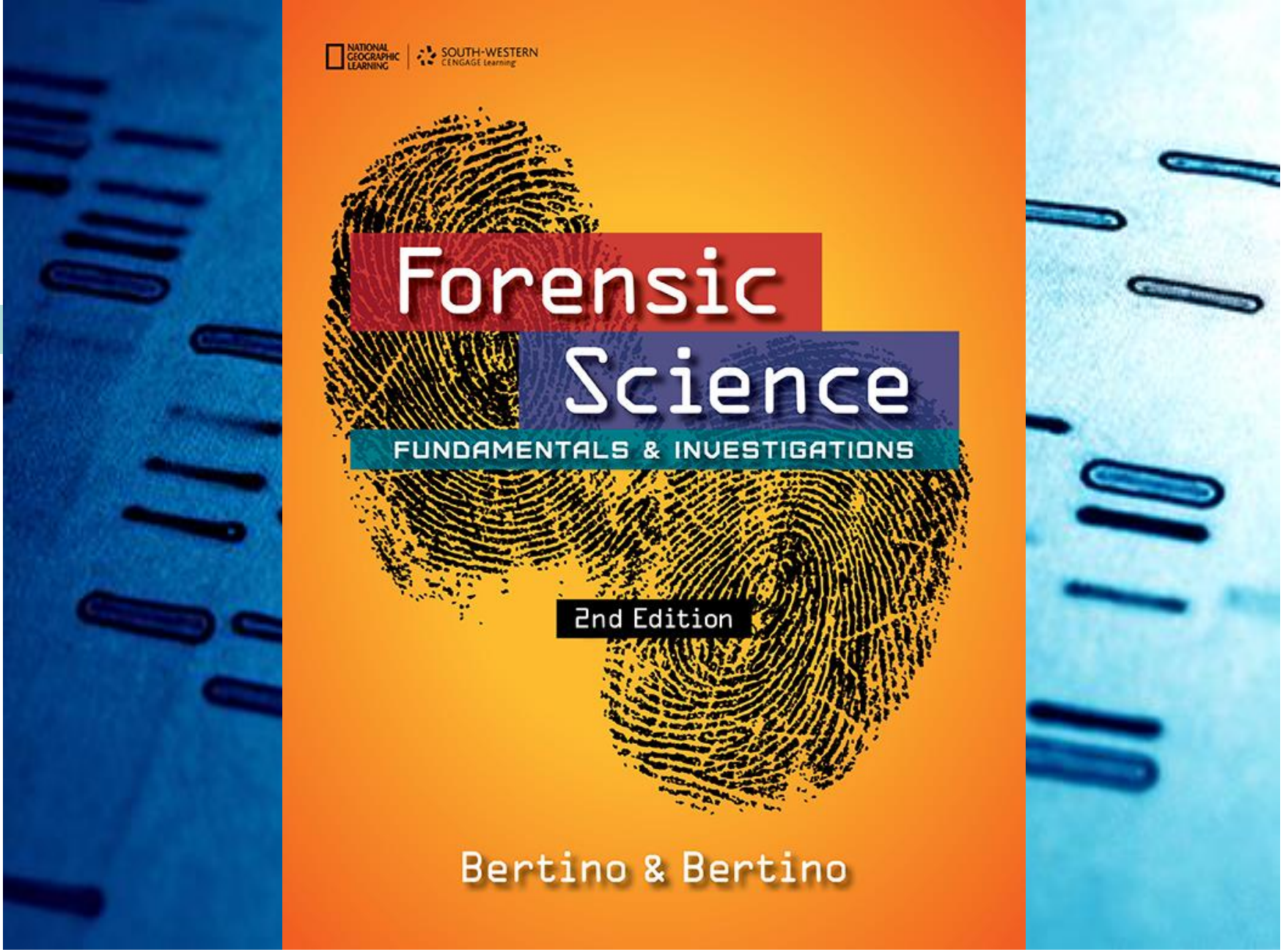


Chapter 3 *Hair Analysis*

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

3.1 Identify the various parts of a hair.

3.2 Describe variations in the structure of the medulla, cortex, and cuticle.

3.3 Distinguish between human and nonhuman animal hair.

3.4 Determine if two examples of hair are likely to be from the same person.

Chapter 3 *Hair Analysis*

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

3.5 Explain how hair can be used in a forensic investigation.

3.6 Calculate the medullary index for a hair.

3.7 Distinguish hairs from individuals belonging to broad racial categories.

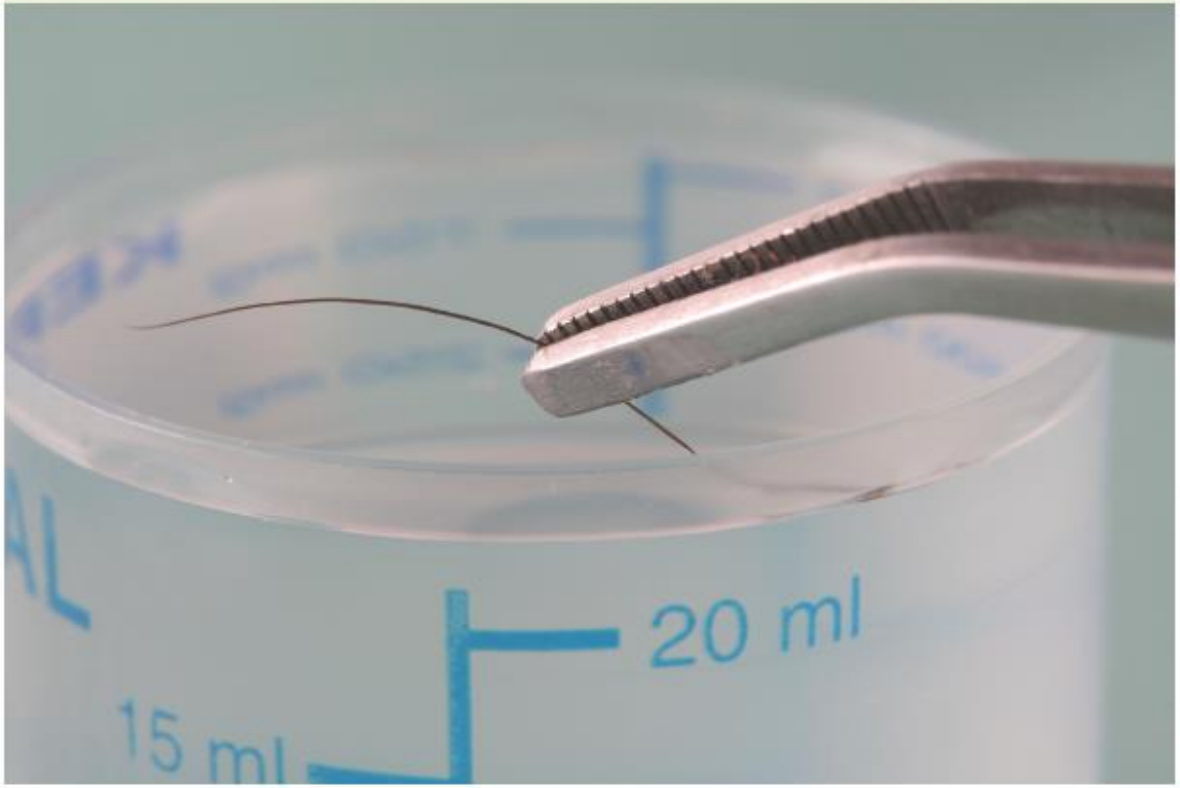
Chapter 3
Vocabulary

- comparison microscope
- cortex
- cuticle
- gas chromatography
- hair follicle
- hair shaft
- keratin
- medulla
- melanin granules
- mitochondrial DNA (mtDNA)
- nuclear DNA

Introduction

- A hair without the follicle and its nuclear DNA cannot provide individual evidence.
- Hair can yield class evidence.
- Chemical tests performed on hair can reveal drugs, toxins, heavy metals and nutritional deficiencies.
- 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

History of Hair Analysis

- 1883: Alfred Swaine Taylor and Thomas Stevenson covered hair in a forensic science text.
- 1910: Victor Balthazard and Marcelle Lambert published a comprehensive study of hair.
- 1934: Dr. Sydney Smith, analyzed hairs side by side using a comparison microscope.
- Today: Standard procedures of hair analysis include microscopic examination and DNA analysis.

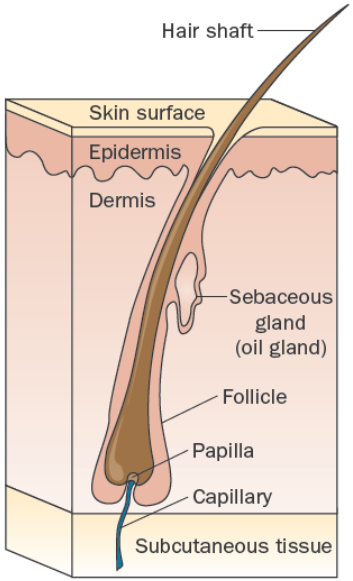
The Functions of Hair

- Regulates body temperature
- Decreases friction
- Protects against sunlight
- Acts as a sense organ
- Humans are born with about 5 million hair follicles.

The Structure of Human Hair

- Human hair consists of a follicle and a shaft.

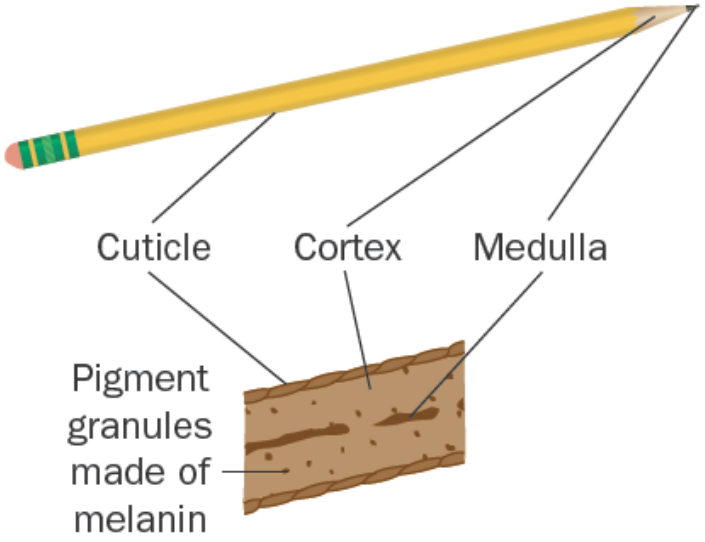
Figure 3-2 *This cross section shows a hair shaft in a hair follicle. If the follicle of the hair is present in evidence, nuclear DNA may be extracted, amplified, and analyzed for use as individual evidence. If no follicle is present, mitochondrial DNA or other characteristics may be analyzed for use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

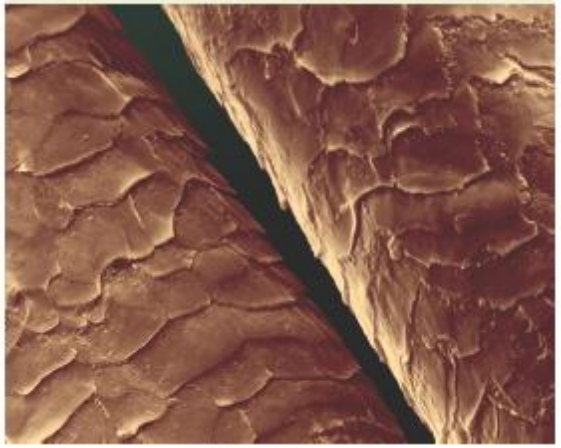
Figure 3-3 *The cross section of a hair shaft is similar to that of a round, wooden pencil.*



The Structure of Human Hair
(continued)

- The cuticle is a transparent outer layer of the hair shaft.

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



Dee Breger/Science Source

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.

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.*

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

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.
  - Anagen stage
  - Lasts approximately 1000 days
- Catagen stage
  - The hair stops growing and the follicle recedes.
- Telogen stage
  - The hair follicle is dormant and hair is easily lost.

Treated Hair

- Hair can be treated in many different ways.

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

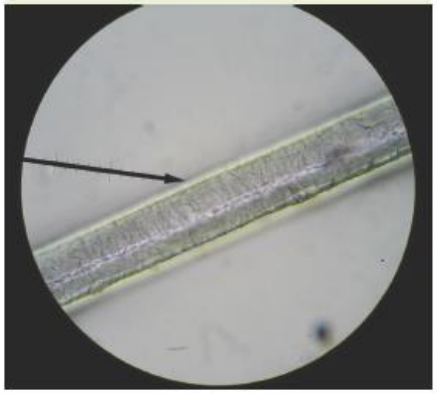


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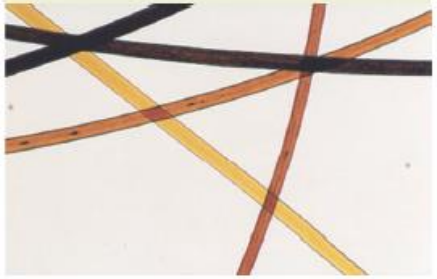
Figure 3-9 *Examples of dyed human hair. Notice the dye stains the entire hair, including the cuticle and cortex.*

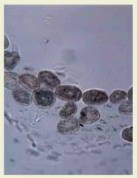
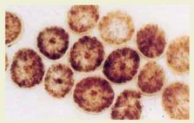
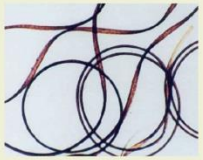


FBI; photos by Sandra Koch & Douglas W. Deedric

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.*

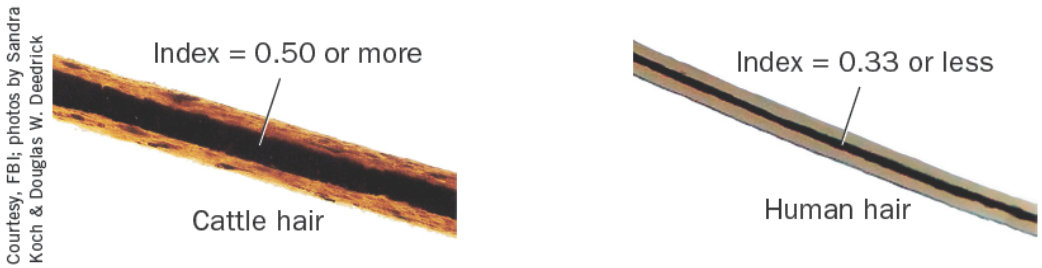
Ancestry	Appearance	Pigment Granules	Cross Section	Other
European	Generally straight or wavy 	Small and evenly distributed	Oval or round of moderate diameter with minimal variation 	Color may be blond, red, brown, or black
Asian	Straight 	Densely distributed	Round with large diameter 	Shaft tends to 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

Animal hair and Human Hair

- Animal hair and human hair have several differences including:
  - The pattern of pigmentation
  - 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.*

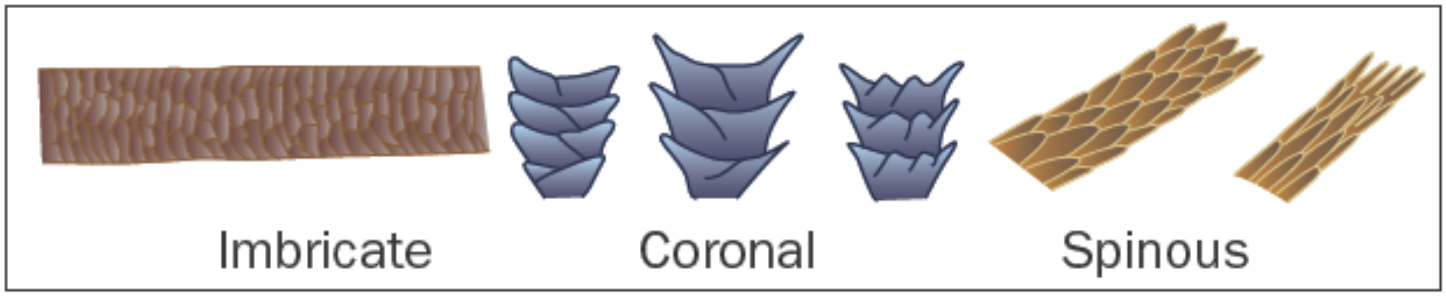


Courtesy, FBI; photos by Sandra Koch & Douglas W. Deedrick

Hair Cuticles

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

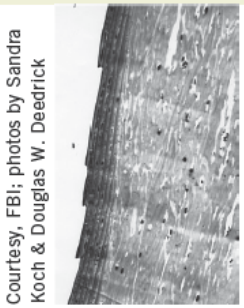
Figure 3-12 *Imbricate (human), coronal (mouse), and spinous (cat) cuticles.*



Electron Microscopes

- Electron microscopes direct a beam of electrons at a sample.
- Electron microscopes 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

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.

Summary

- Hair is a form of evidence that has been used in forensic analysis since the late 19th century.
- Hair is a characteristic shared by all mammals and functions in temperature regulation, reducing friction, protection from light, and as a sense organ.
- Hair consists of a follicle embedded in the skin that produces the shaft.

Summary (continued)

- The shaft is composed of the protein keratin and consists of the outer cuticle, a cortex, and an inner medulla, most of which can vary within and among individuals and among species. The shaft also has pigments and mitochondrial DNA.
- Hair varies in length, medulla type, and cross-sectional shape, depending on where on the body it originates.
- Hair development is divided into three stages: anagen (growth), catagen (resting), and telogen (dormancy).