Chapter 3  The Study of Hair
By the end of this chapter you will be able to:

- Identify the various parts of a hair
- Describe variations in the structure of the medulla, cortex, and cuticle
- Distinguish between human and nonhuman hair
Chapter 3  The Study of Hair
By the end of this chapter you will be able to:

- Determine if two examples of hair are from the same person
- Explain how hair can be used in a forensic investigation
- Calculate the medullary index for a hair
Vocabulary

- **Class evidence**: material that connects an individual or thing to a specific group
- **Comparison microscope**: a compound microscope that allows the side-by-side comparison of samples
- **Cortex**: the region of hair located outside the medulla containing granules of pigment
- **Hair follicle**: the actively growing root of the hair that contains DNA and living cells
Vocabulary

- Individual evidence: a kind of evidence that identifies a particular person or thing
- Keratin: a type of fibrous protein that makes up the majority of the cortex of hair
- Medulla: central core of a hair fiber
- Melanin granules: bits of pigment found in the cortex of a hair
Vocabulary

- Neutron activation analysis: a method of analysis that determines the composition of elements in a sample
- Trace evidence: small but measurable amounts of physical or biological material found at a crime scene
Introduction

- Hair is class evidence
  - Without follicle attached it can only narrow to a group
- Hair can easily be left behind or transferred from one place to another
  - Secondary transfer: when material is moved from one place to another by adhering to clothing or other materials
- Hair does not easily decompose
Introduction

- Hair can provide evidence
  - To racial background
  - To the use of drugs, toxins, and presence of heavy metals
  - To the assessment of nutritional deficiencies
  - If follicle is present DNA evidence can be used to identify individuals
History of Hair Analysis

1. 1883: Alfred Swaine Taylor and Thomas Stevenson covered hair in a forensic science text

2. 1910: Victor Balthazard and Marcelle Lambert published a comprehensive study of hair

3. 1934: Dr. Sydney Smith, analyzed hairs side by side using a comparison microscope

4. Today: chemical tests, neutron activation analysis, and DNA analysis
The Function of Hair

- Regulates body temperature
  - By raising and trapping air for insulation
- Decreases friction
- Protects against sunlight
- Fur is so named because the hair is very dense
- Humans lose hair as they age and only 2% of hair follicles are on the head
The Structure of Hair

- A **follicle** embedded in the skin produces the **hair shaft**
  - The shaft is made of the protein keratin
  - Keratin is a helical protein that makes the hair strong
- Three layers (illustrated at right):
  - the inner **medulla**
  - the **cortex**
  - the outer **cuticle**
The Structure of Hair

- Follicle: club shape at the base of the hair
- Papilla are blood vessels that feed the hair so it can grow
- A bulb surrounds the end of the hair
- Sebaceous gland secretes oil to condition hair
- Nerves and an erector muscle attach so the hair can respond to the environment
Cuticles, Cortex, and Medulla

- Cuticles
- Cortex
- Medulla

Pigment granules made of melanin
Types of Cuticle and Cortex

- **Cuticle:**
  - the transparent outermost layer
  - over-lapping scales that protect the inner layers
  - Point from the proximal end to the distal end
    - This points out younger and older end of the hair
  - Scales on human hair are flattened and narrow, called imbricate
Types of Cuticle and Cortex

Cortex:
- Thickest layer
- Contains most of the pigment granules (melanin)
- Distribution of pigment varies
- Usually denser nearer the cuticle
The Medulla

- The center of the hair
- Can be a hollow tube or filled with cells
- Some people lack this part of the hair
- Others may be fragmented or segmented
- Others may have a doubled medulla
- May be pigmented or not
- Categories in the following five categories
## Types of Medulla

<table>
<thead>
<tr>
<th>Medulla Pattern</th>
<th>Description</th>
<th>Diagram</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Continuous</strong></td>
<td>One unbroken line of color</td>
<td></td>
</tr>
<tr>
<td><strong>Interrupted (Intermittent)</strong></td>
<td>Pigmented line broken at regular intervals</td>
<td></td>
</tr>
<tr>
<td><strong>Fragmented or Segmented</strong></td>
<td>Pigmented line unevenly spaced</td>
<td></td>
</tr>
<tr>
<td><strong>Solid</strong></td>
<td>Pigmented area filling both the medulla and the cortex</td>
<td></td>
</tr>
<tr>
<td><strong>None</strong></td>
<td>No separate pigmentation in the medulla</td>
<td></td>
</tr>
</tbody>
</table>
Types of Hair

- A cross section: circular, triangular, irregular, or flattened
- Shape: influences the curl of the hair
- Texture: coarse or fine
  - Some furs are mixtures of textures
Types of Hair

- Human hair varies on the body in shape and characteristics
  - Head
  - Eyebrows & Lashes
  - Mustache & Beard
  - Underarms
  - Auxiliary or Body hair
  - Pubic
  - 50 hairs are taken from the head and 25 from the pubic region
Types of Hair

- Hair is distinguished by cross-sectional shape
  - Head hair is generally circular or elliptical
  - Eyebrow/lashes are circular but often tapered at the end
  - Beard hairs are generally thick and triangular, coarse, and have doubled medulla
  - Body hairs are either oval or triangular depending on regular shaving
  - Pubic are oval or triangular, diameter may vary, and buckling may be present
  - Arm and leg hair usually has blunt tips but may be frayed
The Life Cycle of Hair

- Hair proceeds through 3 stages as it develops:
  - **Anagen** stage: lasts 1000 days, 80% - 90% of all human hair
    - hair actively grows
    - cells around the follicle rapidly divide and deposit materials in the hair
  - **Catagen** stage: 2% of all hair growth and development
    - hair grows and changes
  - **Telogen** stage: 10% to 18%
    - follicle becomes dormant
Treated Hair

- **Bleaching**
  - disturbs the scales on the cuticle and
  - removes pigment
  - leaves hair brittle and yellowish
  - Artificial leaves a sharp demarcation
  - From the sun is more gradual mark

- **Dyeing** colors the cuticle and the cortex
Treated Hair

- If entire hair is recovered you can determine the last time a hair was colored
  - Hair grows at about 1.3 cm per month
  - Measure length of the naturally colored hair and divide by 1.3 cm will give the time of last coloring
    - If naturally colored section of hair is 2.5 cm, divide by 1.3 cm and you find that the last coloring was 1.9 months ago (about 7 weeks)
    - This can be used to determine if hair belongs to an individual
Racial Differences

- Broad, racial groups do exhibit some shared physical characteristics
- But NOT applicable to all individuals in these groups

Therefore,
- Individual hairs CANNOT be assigned to any of these groups
Animal Hair and Human Hair

- **Pigmentation:**
  - animal hair is denser toward the medulla
  - human hair tends to be denser toward the cuticle
  - Animal hair often has ovoid bodies or dense masses of pigment

- **Banded Color Patterns:**
  - possible in animals
  - not in humans (usually one color along the length)

- **Medulla:** much thicker in animals
Medulla Index—Animals vs. Humans

Medullary index: ratio of the diameter of the medulla to medulla the entire hair

Index = 0.50 or more

Cattle hair

Index = 0.33 or less

Human hair
Animal Hair and Human Hair

- **Spinous**
  - Animals: cuticle scales resemble petals (spinous) or a stack of crowns (coronal)
    - Spinous: cats, seals, and mink
    - Coronal: rodents and bats
- **Coronal**
- **Imbricate**
  - Humans: commonly flattened and narrow (imbricate)
Using Hair in an Investigation

- Hair can be collected in the following methods
  - Plucking, shaking, or scraping surfaces
  - Large amounts can be collected by vacuum
  - Tape may be used also
- Once collected, hair is compared to victim or suspect hair from the 6 major regions of the body
- Initial examination is under low power microscopes to examine the cuticle
Using Hair in an Investigation

- Macroscopic investigations indicate
  - Length, color, curliness

- Microscopy shows
  - Pattern of medulla, pigmentation of cortex, types of scales on cuticle
  - Usual magnification is between 40 and 400 x
  - Comparison microscope helps to compare and match hair samples by looking at two samples at the same time
Using Hair in an Investigation

- Phase contrast microscopy shows
  - presence of dye or other treatments
    - Used with fluorescence microscope
    - Uses light of a particular wavelength
    - Dye absorbs light and emits a different wavelength
  - Method involves special objective lenses and condensers that focus light that travels through objects with different refractive indexes
    - Allows for more contrast in translucent particles
- Electron microscopes yield yet more detail
Using Hair in an Investigation

Note the overlapping scales and the pigment granules in the cortex
Testing for Substances in the Hair Shaft

- **Chemical tests**
  - presence of various substances
  - Looking for poisons (lead, arsenic) or drugs
  - The hair is dissolved and then checked for substances

- **Examining a hair shaft**
  - timeline for exposure to toxins
  - A timeline can be developed as to when the poisoning or drug use occurred
  - This process is similar to the coloring test
  - The hair would be studied in sections of known length from the root
Testing for Substances in the Hair Shaft

- **Neutron Activation Analysis (NAA)**
  - Identifies up to 14 different substances in 2 cm of hair
  - Hair is placed in a nuclear reactor and bombarded with high-energy neutrons
  - Different elements will give off gamma radiation with different signals
  - Signals can be used to determine concentrations of elements in the sample
  - Can identify antimony, argon, bromine, copper, gold, manganese, silver, sodium, and zinc
  - The probability of two people having the same concentration of 9 elements is about 1 in a million
Testing the Hair Follicle

- If the whole hair is removed it will have the follicular tag (the follicle) attached
- Microscopic assessment
  - Cost effective and quick and is used as the first step
  - Usually only provides class identification
- Blood test
  - Determine blood type from blood proteins
- DNA analysis
  - Identification with a high degree of confidence
Microscopic Assessment

- Preparation
Hair functions to regulate temperature, reduce friction, protect from light, and produce sensory data.

Hair consists of a (a) hair shaft produced by a (b) follicle embedded in the skin.

The shaft consists of an outer cuticle, a cortex, and an inner medulla.

Hair characteristics vary depending on location on the body.
Summary

- Hair development has three stages: anagen, catagen, and telogen.
- Various hair treatments produce characteristic effects useful to forensic experts.
- Some characteristics can be grouped into general racial categories.
- Forensic experts examine hair using chemicals, light, electrons, neutrons, and DNA sequencing.