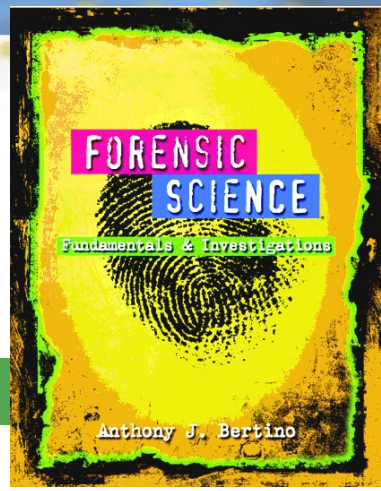
Chapter 3 *The Study of Hair*

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 measureable 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

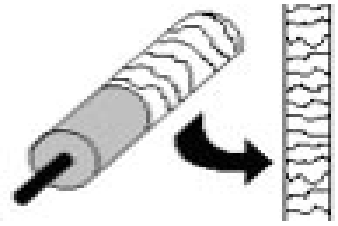
1. 1883: Alfred Swaine Taylor and Thomas Stevenson covered hair in a forensic science text
2. 1910: Victor Balthazard and Marcelle Lambert published a comprehensive study of hair
3. 1934: Dr. Sydney Smith, analyzed hairs side by side using a comparison microscope
4. Today: chemical tests, neutron activation 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

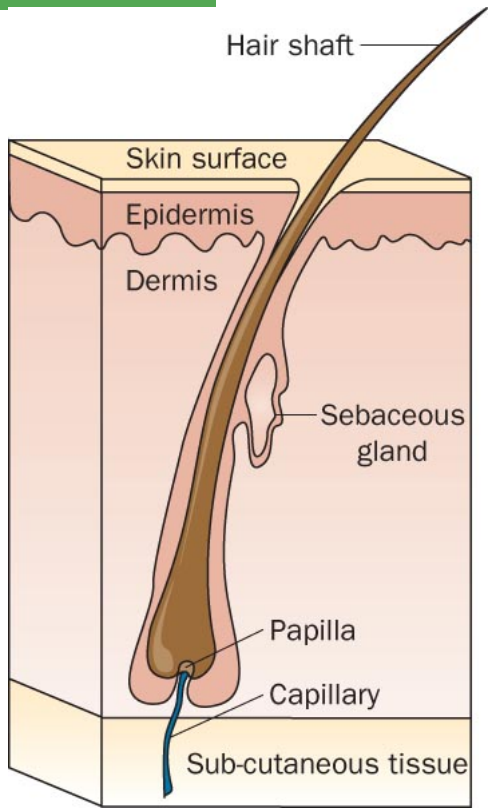
The Structure of Hair

- 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

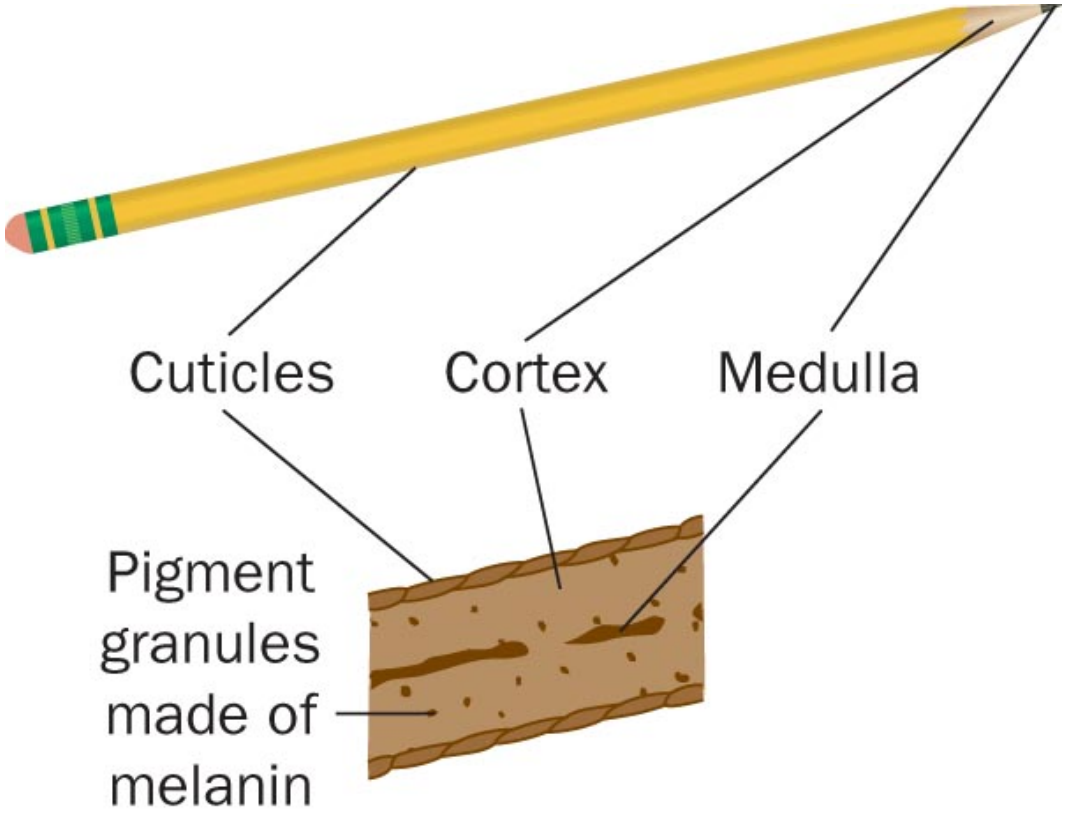


The Structure of Hair

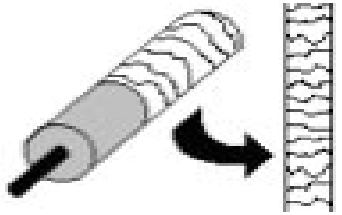
- Follicle: club shape at the base of the hair
- Papilla are blood vessels that feed the hair so it can grow
- A bulb surround the end of the hair
- Sebaceous gland secretes oil to condition hair
- Nerves and an erector muscle attach so the hair can respond to the environment



Cuticles, Cortex, and Medulla



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

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

Buckled

Blunt

Double Medulla

- 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

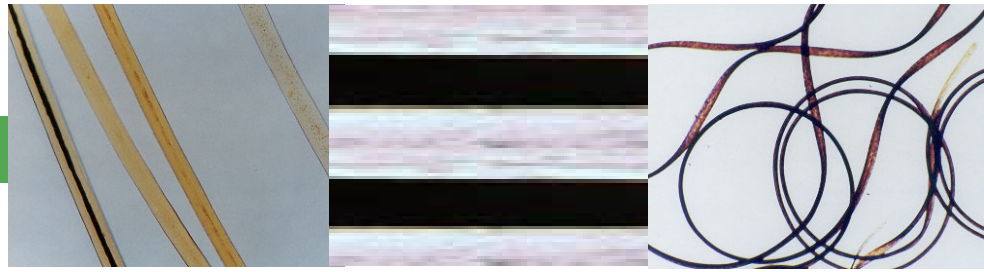
Treated Hair

- 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

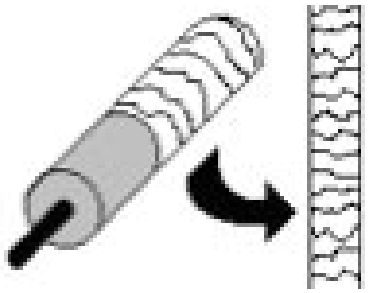


- Broad, racial groups do exhibit some shared physical characteristics
- But NOT applicable to all individuals in these groups

Therefore,

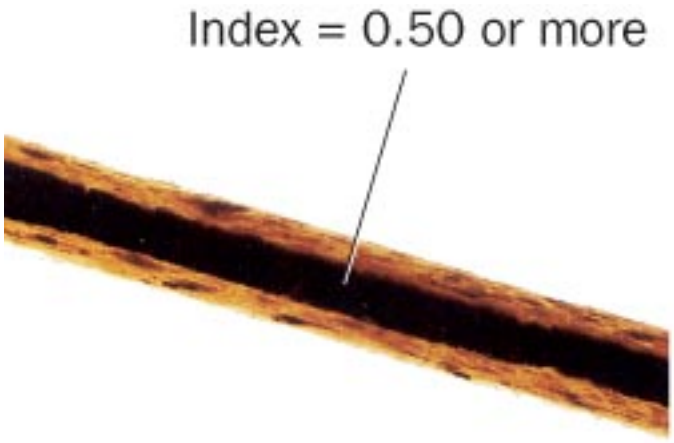
- Individual hairs CANNOT be assigned to any of these groups

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



Cattle hair

Human hair

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

Animal Hair and Human Hair

Spinous

Coronal

Imbricate

- Animals: cuticle scales resemble petals (spinous) or a stack of crowns (coronal)
  - Spinous: cats, seals, and mink
  - Coronal: rodents and bats
- 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

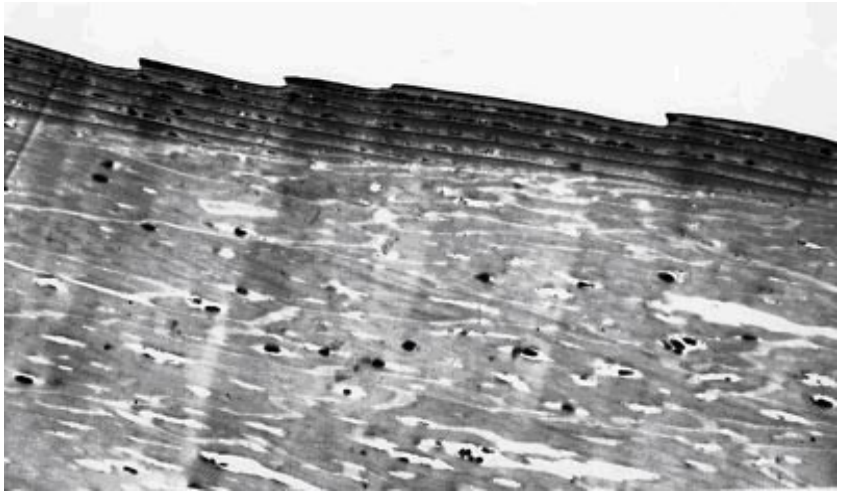
- Macroscopic investigations indicate
  - Length, color, curliness
- Microscopy shows
  - Pattern of medulla, pigmentation of cortex, types of scales on cuticle
  - Usual magnification is between 40 and 400 x
  - Comparison microscope helps to compare and match hair samples by looking at two samples 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

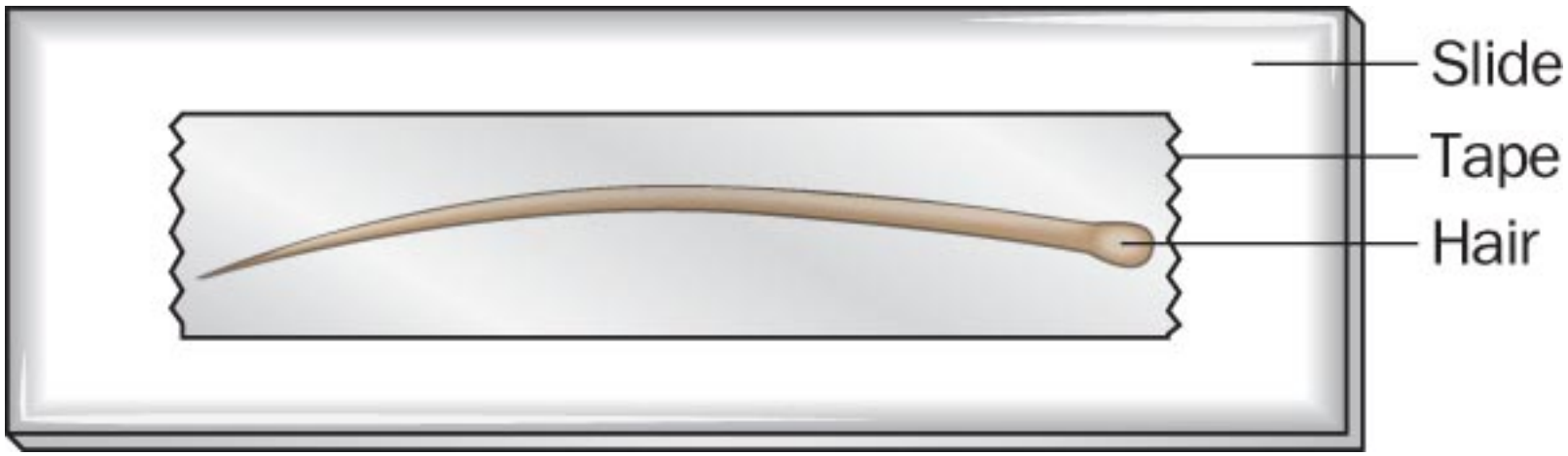
- Neutron Activation Analysis (NAA)
  - Identifies up to 14 different substances in 2 cm of hair
  - Hair is placed in a nuclear reactor and bombarded with high-energy neutrons
  - Different elements will give off gamma radiation w/ different signals
  - Signals can be used to determine concentrations 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



. . . . . Summary . . . .

- 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.