Come in and get your notebooks out. We have notes today!
All Mammals have hair. Hair is used for many different reasons including:

- Regulating Body Temperature
- Sense Organ
- Protection from the Elements and Sunlight.

When a mammal's hair is dense, it is referred to as Fur.
Anatomy of Hair

In Forensics, we examine the Hair Shaft and follicle.
Anatomy of Hair

Hair Shaft is made up of 3 parts
Cuticle - Protective outer layer of hair. Shows the “scales” of hair.

Cortex - Shows the color of the hair and determines shape. Sometimes color, or pigments, are not evenly distributed within the hair.

Medulla - The central canal running through the middle of the hair. Sometimes the medulla will be solid, or dashed, or may not even appear.
Hair & Fiber

Come in and get your notebooks out. We have notes today!
Hair is considered CLASS EVIDENCE.

- Human hair is one of the most frequently found pieces of evidence at the scene of a violent crime. It can provide a link between the criminal and the crime.

- From hair one can determine:
  - If the source is human or animal
  - Race (sometimes)
  - Origin of the location on the source’s body
  - Whether the hair was forcibly removed
  - If the hair has been treated with chemicals
  - If drugs have been ingested
What Can Hair Examination Show:

- Finding hair shows there has been physical contact between a victim and perpetrator
- When found, it is submitted to the lab with standard samples
- It can provide strong evidence for placing someone at the scene
- First step of examination begins with color, structure, and morphology
- Then progresses to DNA testing

Typical hair that is found:

- Scalp
- Beard
- Eyelash
- Body hair
- Pubic Hair
The Structure of Hair

Hair can be broken into 2 parts: the **Follicle** and the **Hair Shaft**. A follicle is the part of the skin that grows hair.

Hair grows from its root, continues into the shaft, and terminates at the tip end.

The Hair Shaft is made up of 3 layers: the Cortex, Cuticle, and Medulla.
Forensic Scientists Examine The Hair Shaft

**Hair Shaft Components**

- **Cuticle**—outside covering, made of overlapping scales
- **Cortex**—inner layer made of keratin and imbedded with pigment; also contains air sacs called cortical fusi
- **Medulla**—inside layer running down the center of the cortex
A Basis for Comparison.

A open pencil can remind us of what the hair shaft will look like.
Hair Shaft Ends

Burned
Cut
Razored
Split
The Cuticle

- Gives hair resistance to chemical breakdown and retains its structural features
- Overlapping scales always point towards tip end of hair.
- Scale pattern allows for differentiation of species
FIGURE 10–2 Scale patterns of various types of hair. (a) Human head hair (600×), (b) dog (1250×), (c) deer (120×), (d) rabbit (300×), (e) cat (2000×), and (f) horse (450×). Courtesy International Scientific Instruments, Mountain View, Calif., and New Jersey State Police.
The Cortex

- Is found within the cuticle and gives the hair its shape.

- It is embedded with the pigment granules melanin that give hair its color.

- Color, shape, and distribution of these granules provide important comparison points.

- Cortical fusi—air spaces, usually found near the root but may be found throughout the hair shaft.
The Medulla

- Looks like a central canal running thru the hair
- **Medullary index** measures the diameter of the medulla to that of the hair shaft (fraction)
- In humans, it is less than 1/3, most other animals is 1/2 or greater
- Medulla may be **patterned** (unisereal, lattice, multisereal, vacuolated), **amorphous** (continuous, interrupted, fragmented), or **absent**
- Human head hairs: generally none or fragmented
- Exception is Asian race: usually continuous
The Medulla

- Most animals have continuous or interrupted
- Humans and some animals have medulla that are cylinder shaped
- Other animals have medulla with patterns
- Cat has what looks like a string of pearls
- Deer—circular cells running whole length & width
- There is a database of the 35 most common animal hairs found at crime scenes
<table>
<thead>
<tr>
<th>Medulla Pattern</th>
<th>Description</th>
<th>Diagram</th>
</tr>
</thead>
<tbody>
<tr>
<td>Continuous</td>
<td>One unbroken line of color</td>
<td></td>
</tr>
<tr>
<td>Interrupted (Intermittent)</td>
<td>Pigmented line broken at regular intervals</td>
<td></td>
</tr>
<tr>
<td>Fragmented or Segmented</td>
<td>Pigmented line unevenly spaced</td>
<td></td>
</tr>
<tr>
<td>Solid</td>
<td>Pigmented area filling both the medulla and the cortex</td>
<td></td>
</tr>
<tr>
<td>None</td>
<td>No separate pigmentation in the medulla</td>
<td></td>
</tr>
</tbody>
</table>
Humans versus common animals

**FIGURE 10-4** Medulla patterns for various types of hair. (a) Human head hair (400×), (b) dog (400×), (c) deer (500×), (d) rabbit (450×), (e) cat (400×), and (f) mouse (500×).
Can be straight, curly or kinky depending on the cross-section, which may be round, oval or crescent-shaped.
Types of Hair

- **Scalp**: has a uniform diameter in cross-section
- **Beard**: coarse, curved, and when viewed in cross-section has a distinctive triangular shape
- **Eyebrow, nose, ear, and eyelid**: shorter and stubbier than scalp hair and have wide medullas
- **Axillary**: have unevenly distributed pigments; end in a fine point when uncut
- **Auxiliary**: oval or triangular, depending on whether the body region has been regularly shaved
- **Pubic**: oval or triangular
Human head hair grows in 3 stages:

- **Anagen phase** (initial growth): lasts up to six years; root is attached to follicle for continued growth; *flame-shaped* appearance. When pulled out, it will have a follicular tag. This tissue has the richest source of DNA and can be analyzed for individualization.

- **Catagen phase**: Hair continues to grow but at a slower rate which can last 2 to 3 weeks; roots have an *elongated appearance* due to shrinking and hair being pushed out follicle.

- **Telogen phase**: hair growth ends and root takes a *club-shape*; in 2 to 6 months, the hair will be pushed out and shed.
FIGURE 10-6  Hair roots in the (a) anagen phase, (b) catagen phase, and (c) telogen phase (100x). Courtesy Charles A. Linch
Hair Comparison

- Color
- Length
- Diameter
- Distribution, shape and color intensity of pigment granules
  - Dyed hair has color in cuticle and cortex
  - Bleaching removes pigment and gives a yellow tint
- Scale types
- Presence or absence of medulla
- Medullary type
- Medullary pattern
- Medullary index
ID and Comparison of Hair

- Prime purpose to examine hair is to see whether it is human or animal or to determine whether hair retrieved at a crime scene compares with a person in question

- In most cases, comparison is done on head and pubic hair

- Scale structure, medullary index, and medullary shape are important in hair ID
Factors in Comparison of Hair

- Animal is usually distinguished from human hair easily
- Human hair comparisons must be done with caution
- Hair has variable characteristics not only from person to person but also within a single person
- Criminalist is interested in matching color, length, diameter
- Others are the presence/absence of medulla, distribution, shape, and color intensity of granules in the cortex
- Microscope may distinguish dyed/bleached vs natural hair
- Dyed color is present in the cuticle and cortex
- Bleaching removes pigment from hair and leaves a yellowish tint If hair has grown from last bleaching or dye, the new hair will have a distinct color difference
- An estimate of time can since dyeing or bleaching can be made because hair grows about 1.3 cm a month
Microscopic Exam of Hair

- A comparison microscope allows the examiner to view the questioned and known hair together, side by side.
- Comparison may include or exclude questioned hairs against standard hairs.
- This is questionable because it is dependent on the skills and integrity of the analyst.
- If it can't be excluded, DNA analysis must be carried out.
- FBI published errors made by microscopic exam.
- Between 1996 and 2000, 11 percent of hairs (9 out of 80) in which FBI found a positive microscopic match between questioned and standard hairs were found to be nonmatches when subjected to DNA analysis.
Can the body area in which hair originated be determined?

• Normally is easy

• Scalp hairs show little diameter variation & have more uniform distribution of pigment

• Pubic hair is short and curly with wide variation in diameter, usually have continuous medullae

• Beard hair is coarse, triangular in cross-section, have blunt tips from shaving
Can age and sex be determined?

• Age cannot except for infant hair

• Infant hair tends to be fine, short, and has fine pigmentation

• Presence of dye or bleach may offer some clues as to which sex the individual is

• Recovery of nuclear DNA (passed down to us by both parents) from tissue adhering to hair or from root structure of hair will determine sex
Is it possible to determine if hair was forcibly removed?

- Yes, exam may determine whether the hair shed or was pulled from skin
- Root with follicular tissue indicates it was pulled out by a person or by brushing hair
- Hair naturally shedding has a bulbous-shaped root free of tissue
- Sometimes, the root does not possess tissue even thought the hair was pulled out
- Hair pulled quickly are more likely to have tissue
- Hair removed slowly will not
Are efforts being made to individualize human hair?

- Can link human hair to a particular person by nuclear DNA in the hair root or follicular tissue.
- Follicular tissue is the richest source of DNA associated with hair.
- Examiners have a higher success rate in extracting DNA from hair roots in the anagen phase or from anagen entering catagen.
- Telogen phase has an inadequate amount of DNA.
- When there is no tissue or root, there is mitochondrial DNA (found in cellular material outside the nucleus).
- This is passed down to us by our mother only.
- Many more copies are located in our cells than nuclear DNA.
- Success rate of finding and typing Mitochondrial is greater.
Can DNA individualize a human hair?

- Nuclear DNA can
- Mitochondrial cannot but can exclude a significant portion of a population as potential contributors
- Combination of a positive microscopic exam and nuclear or mitochondrial DNA strongly links a questioned hair and standard
- BUT mitochondrial DNA can’t distinguish hairs from different individuals who are maternally related
Collection/Preservation

• Questioned hairs must be submitted with an adequate number of standard samples
• Questioned and standards must come from same body location from victim, suspects, and other who may have deposited hair at the scene.
• Comparisons will usually involve head or pubic hair
• Head: collect 50 full-length hairs from all areas of scalp
• Pubic: collect 24 full-length pubic hair
• In rape cases: Comb pubic area with clean comb to remove all loose hair before sampling for standard samples
• Comb should be packaged in separate envelope
• Autopsy: hair is always collected just in case
Hair toxicology

- Advantages:
  - Easy to collect and store
  - Is externally available
  - Can provide information on the individual’s history of drug use or of poisoning.

- Collections must be taken from different locations on the body to get an accurate timeline.
Napoleon died in exile in 1821. By analyzing his hair, some investigators suggest he was poisoned by the deliberate administration of arsenic; others suggest that it was vapors from the dyes in the wallpaper that did him in.