Trace Evidence: Hair
Forensic Science
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Hair is...

- A slender threadlike outgrowth from the follicles of the skin of **mammals**
- Found all over our bodies
  - Head
  - Face
  - Chest
  - Limbs (arms and legs)
  - Pubic region

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*Because many people have similar hair structure and color, hair is considered class evidence.*
Structure

• Major components
  – **Keratin** is a protein that makes up most of the hair shaft.
  – **Melanin** is a pigment that gives hair its color.
  – Redheads have **pheomelanin** instead of melanin.
Structure – pencil analogy

- **Cortex** – the main body (wooden portion)
- **Medulla** – the central cell of the cortex that is not always present in every hair (pencil lead)
- **Cuticle** – a layer of scales covering the hair shaft (yellow paint)
Structure (continued)
Characteristics
Medulla Variations

Continuous Clear Medulla

Continuous Opaque Medulla
Medulla Variations

Discontinuous Medulla

Wafer Medulla
Medulla Variations

Bubbly or Cellular Medulla

Coarse Cellular Appearance (no visible medulla)
Pigment

- **Colors** – light, medium, dark; reddish-brown, brown, black, etc.
- **Granular Sizes** – fine, moderate, large
- **Density** – light, moderate, heavy
- **Distribution** – random, peripheral, even, central, one-sided

Dyed Human Hair
Pigment Distribution

One-Sided

Peripheral in Human Hair

Random in Animal Hair

Central in Red Human Hair
Ovoid Bodies

- **Ovoid bodies** – spherical to oval heavily pigmented structures found mostly in cattle and dog hairs, but present in some human hairs

Ovoid Bodies in human hair

Ovoid Bodies in dog hair
Cortical Fusi

- **Cortical fusi** – elongated, spindle-shaped air spaces in the cortex
Root (Proximal End): Growth Stages

- **Anagen root** – an active growth stage, often found with a ribbon-like tip and a follicular tag (a soft tissue from the follicle)

- **Catagen root** – the intermediate stage of growth

- **Telogen root** – a resting stage, has a bulb-like shape. Often found with very little pigment and an abundance of cortical fusi.
Roots (continued)

Anagen

Telogen

Catagen

follicular tag
Follicular Tag

- Hairs that are forcibly removed often end up with a **follicular tag** (a soft tissue from the follicle) attached to the roots.

- The follicular material may be suitable for nuclear **DNA analysis**.
Roots (continued)

• **Postmortem Root Band** (aka "Dead man's root") a dark band that may appear near the root of the hair originating from a decomposing body
Other Distal End Configurations

Scissor-cut

Razor-cut

Burnt hair

Abraded

Rounded

Broken
Hair – Racial Origin

- Hair from people of different ethnic origin has distinctive characteristics that can be compared in the forensics lab.
- Anthropologists classify humans into groups based on phenotypic characteristics such as cranial and skeletal morphology.

- **Caucasoid**: descendant of peoples indigenous to Europe, N Africa, SW Asia, and the Indian subcontinent.

- **Mongoloid**: descendant of peoples indigenous to central and eastern Asia; also Eskimos and Native Americans.

- **Negroid**: descendant of peoples indigenous to sub-Saharan Africa.
Racial Origin

• Hair characteristics that can be compared in the forensics lab include:

  – shaft diameter
  – shape of cross-section
  – pigment density and distribution
  – cuticle thickness, etc.
Racial Origin

• **Caucasoid**
  – moderate shaft diameter with very little variation
  – light to moderate pigment density with fairly even distribution
  – *oval-shaped cross-section*
Racial Origin (continued)

- **Mongoloid**
  - coarse shaft diameter
  - streaky pigments with heavy density
  - thick cuticle
  - *round cross-section*
Racial Origin (continued)

Mongoloid Head Hairs
Racial Origin (continued)

- **Negroid**
  - fine to moderate shaft diameter
  - considerable variation throughout the hair shaft with prominent twists and curls
  - heavy pigment density with pigment clumpings
  - flattened cross-section
Racial Origin (continued)

Negroid head hairs
Variations

Why do we need to examine each hair sample from root to tip?

Five Regions of a single head hair
Variations (continued)

One person's head hair
One person of multiple race

These within-individual variations are why it’s important to sample multiple hairs from each suspect.
Somatic (Body Area) Origin

Hairs from different parts of the body exhibit different characteristics:

• **Head hairs**
  – Typically much longer than other hairs on the body
  – Generally soft and most likely to have artificial treatment (bleaching, dyes)

• **Pubic hairs**
  – Typically coarse in diameter with wide variations
  – Buckling/bending is a special characteristic found in pubic hairs
Somatic Origin (continued)

- **Limb hairs** (arm or leg)
  - Fine diameter with little variation
  - Arc-like, gross appearance
  - Tips are usually tapered, often blunt and abraded, rounded scale ends due to wear
  - Soft texture

- **Facial hairs** (beard/mustache)
  - Very coarse diameter with irregular or triangular cross-sections
  - Very broad and continuous medulla
  - Medulla may be double
  - Stiff texture
Somatic Origin (continued)

- **Chest hairs**
  - Moderate and variable shaft diameter; tips often darker in color
  - Long and fine, arc-like
  - May have granular medulla
  - Stiff

- **Auxiliary (underarm) hairs**
  - Resemble pubic hairs in general appearance, but less buckling
  - Fine tip
Somatic Origin (continued)

- **Other body hairs**
  - Eyebrow: stubby, saber-like appearance
  - Eyelash: short and stubby, with a saber-like appearance
  - Trunk: a combination of limb and pubic hairs
Human vs. Animal Hair

3 Main Differences:
- pigment/color pattern
- medulla thickness and shape
- cuticle scale shape

Human hair color is fairly constant throughout the shaft whereas animal hair can abruptly change color.
Human vs. Animal Hair - Medulla

The medulla is typically wider and more well defined in animal hair.
Human vs. Animal Hair - Medulla

The medulla in animal hairs can have a very distinctive pattern.

- Uniserial Ladder Medulla
- Multiserial Ladder Medulla
- Cellular Medulla
Human vs. Animal Hair - Scales

The cuticle (outer layer) of hair is made up of overlapping scales that have different shapes in different organisms.

Imbricate Scales Diagram (humans have this)

Coronal Scales Diagram

Spinous Scales Diagram
Human vs. Animal Hair - Scales

- **imbricate** scales in human hair
- **coronal** scales in bat hair
- **spinous** scales in mink hair
- **isodiametric** scales in deer hair (like fish scales)
# Human vs. Animal Hair

## 3 Main differences

<table>
<thead>
<tr>
<th></th>
<th>Human Hair</th>
<th>Animal Hair</th>
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<tbody>
<tr>
<td><strong>Pigment</strong></td>
<td>color and pigmentation is constant throughout the hair shaft</td>
<td>can have abrupt color changes</td>
</tr>
<tr>
<td><strong>Medulla</strong></td>
<td>thin, ~1/3 of the hair shaft diameter; amorphous</td>
<td>very wide, well-defined (with certain patterns)</td>
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<tr>
<td><strong>Scale Structure</strong></td>
<td>has overlapping imbricate scales</td>
<td>varies widely; may be imbricate, coronal, spinous, etc.</td>
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Animal Hairs Identification

• **2 types of animal hairs**
  – **Guard hair**: coarse diameter, provides protection, “outer fur”
  – **Fur hair**: fine diameter, provides insulation, “under fur”

• **3 major groups identified by microscopic appearance**
  – Deer and antelope family
  – Commercial fur animals (rabbit, mink, etc.)
  – Domestic animals
Deer and Antelope Family

- Distinguished based on their isodiametric scales (like fish scales) and wineglass-shaped root
  - Deer
  - Caribou
  - Elk
  - Moose
  - Antelopes
Commercial Fur Animals

- Rabbit
- Mink
- Muskrat
- Chinchilla
- Seal
- Raccoon
- Fox
- Beaver
- Bear
Domestic Animals

- Generally amorphous medullae
- Characteristic root shapes
- Dog
- Cat
- Cattle
- Horse
Domestic Animals (continued)

It is usually necessary that the root be present in order for one to distinguish between dog and cat (or between cattle and horse).

- Elongated
- No distinct shape
- Fibrils frayed at base of root

- Spade-shaped root
Domestic Animals (continued)

- **Cattle hair**
  - Very coarse diameter
  - Abundance of ovoid bodies
  - Medullae continue into the elongated root area

- **Horse hair**
  - Few ovoid bodies
  - Bulb-shaped root
Diseases affecting hair

• Certain diseases or deficiencies may result in changes in the appearance of hair.

**Pili annulati** – ringed or banded hairs

**Trichorrhexis nodosa** - conspicuous nodes due to immunodeficiency or small bowel disorder

**Parasites** - egg sack of head lice
Hair Comparisons

• **Comparison microscope**
  – 2 compound microscopes connected together with an optical bridge
  – Enables side-by-side comparisons
  – Typical magnification from 100X to 250X
Hair Comparisons (continued)

• **Information NOT provided by a hair examination**
  – Age
  – Gender
  – Unless nuclear DNA analysis is performed on its follicular tag

• **Information provided by a hair examination**
  – Is it human or animal hair?
  – What is the possible race of the donor?
  – What area of the body did it come from?
  – Could it have originated from the donor of the known standards?

• **Hair can also be used to distinguish between identical twins (who cannot be distinguished based on their DNA).**
  – because of the environmental effects on hair such as
    • weather exposure, diet, artificial treatment, etc.
Hair Comparisons (continued)

Three conclusions that can be reached in hair comparisons:

1) Similar microscopic characteristics – the questioned hairs **could have** originated from the source of the known hair standards. (*Hair is class evidence!*)

2) Dissimilar microscopic characteristics – the questioned hairs **did not** originate from the source represented by the known hair standards

3) Both similar and slightly different microscopic characteristics – **inconclusive**
Significance of Hair Evidence

• **The frequency of contact** between a victim and a suspect, as well as the crime scene, is a big factor in interpreting the significance of hair evidence.

• **Examples**
  - The pubic hair of a recent ex-boyfriend found at the scene of a sexual assault
  - A husband who is suspected of murdering his wife at home
  - A missing child's hair in the backseat of a former nanny's car
  - A missing child's hair in the backseat of a cleaning lady's car
  - A stepfather's head hair found on a little girl's underwear
  - A stepfather's pubic hair found in the crotch area of a little girl's underwear
Resources


