Trace Evidence: Hairs and Fibers

http://media.popularmechanics.com/images/PMX0706FORENSICSHairSmall.jpg

Forensic Science
Central Focus

- Students will understand how forensic scientists use observational, physical, chemical, and biological tests to analyze hair and fiber evidence collected at a crime scene. Students will understand how to differentiate hairs and fibers and compare victim and suspect samples to help exclude or include potential suspects.
• SFS1b. Distinguish and categorize physical and trace evidence
• SFS1c. Determine the proper techniques to search, isolate, collect, and record trace evidence.
• SFS2d. Evaluate the relevance of possible evidence at the site of investigation
• SFS2b. Analyze the morphology and types of hair and fibers
Essential Questions – Day 1

- What is trace evidence?
- How is hair evidence used in forensic science cases?
- How do you individualize hair evidence?
- What features distinguish animal and human hair?
Learning Targets – I can...

SFS1d-LK7: Define trace evidence.
SFS2b-LK8: Explain how hair is used as evidence.
SFS2b-LK9: Identify the stages of hair growth
SFS2b-LR6: Compare/contrast presumptive vs confirmatory evidence.
SFS1d-LR7: Classify hair and fibers based on the categories from Unit 2 (class vs individual, indirect, circumstantial, transfer, etc).
SFS2b-LR8: Interpret hair evidence using morphological and structural features (including medullary index, calculating growth).
SFS2b-LS3: Observe hair morphological and structural features using a compound microscope.
What is Trace Evidence?

- Trace = any small pieces of material, man-made or naturally occurring
- Evidence transferred between individuals/objects when a crime is committed
FBI’s Trace Evidence Unit

Trace Evidence Unit: “identifies and compares specific types of trace materials that could be transferred during the commission of a violent crime. These trace materials include:

human hair, animal hair, textile fibers and fabric, rope, feathers, soil, glass, and building materials.”
Microscopic comparison: subjective analysis - dependent on skills/integrity of the analyst

1996-2000 11% of hairs that were positive under microscope were later found to be non-matches by DNA

Presumptive Evidence
- Presumptive-regarded as such by presumption; based on inference. (dictionary.com)
Presumptive Evidence: does NOT provide ABSOLUTE proof for what the investigator is trying to determine

Conclusive Evidence: good/hard proof for what the investigator is looking for
can be determined by the sample’s length, shape, size, color, and other physical characteristics.
Six types distinguished by Forensic Scientists by looking at cross-sectional shape:

- Head
- Eyebrows/eyelashes
- Beard and mustache
- Underarm
- Auxiliary or body
- Pubic
Biology of Hair

- Made of keratin.
- Grows from the hair **follicle** (skin appendage).
- Our hair follicles develop during **fetal** development; NO new follicles are produced after birth.
- Only 2% of hair follicles are on the head.
Cross-section of skin
Morphology of Hair

- **Bulb/root**: portion embedded in follicle
- **Shaft** of the hair extends out of the hair follicle
  - Terminates at the tip end
- In order to test hair evidence for DNA, the **root** must be present.
Phases of hair growth

- **Anagen**: initial growth stage-follicle actively producing
  - May last up to 7 years
  - Some hairs have a follicular tag: contains the hair’s nuclear DNA
  - 80-90% of head hair follicles in this stage

- **Catagen**: transition stage; roots are elongated and root shrinks
  - 2% of head hairs are in this stage

- **Telogen phase**: final growth phase; hair naturally falls out.
  - 10-18% of head hairs in this stage

https://www.youtube.com/watch?v=Gxgy9k_SdZs&list=PLeHdnGTZyYCngJ2DkcUpXoQL9uDjm5fKA&index=48
Roots of hair

Fell out (Telogen phase)  Pulled-out with force

Images from FBI.gov
Hair Structure

Hair is composed of three principal parts:

- **Cuticle** – outer coating composed of overlapping scales
- **Cortex** – protein-rich structure around the medulla that contains pigment, main body of the shaft
- **Medulla** – central core (may be absent)

Hair structure has been compared to a **pencil** with the medulla being the **lead**, the cortex being the **wood** and the cuticle being the **paint** on the outside.

http://library.thinkquest.org/04oct/00206/lesson.htm#t_hair
**Cuticle**

Varies in:

- Its **scales**, 
  - How many there are per centimeter,
  - How much they overlap,
  - Their overall shape, and
  - How much they protrude from the surface
- Its **thickness**, and
- Whether or not it contains **pigment**.

Cuticle characteristics: important in distinguishing between hairs of different **species** but are often not useful in distinguishing between different **people**.

Info: http://library.thinkquest.org/04oct/00206/lesson.htm#t_hair  
Animal vs Human Hair

The outermost layer of the hair shaft (the cuticle), is typically different in animals and humans.

- The cuticle scales in animals tend to resemble petals (spinous) or they give the appearance of a stack of crowns (coronal).
- The cuticle scales in humans commonly are flattened and narrow (imbricate).
Cortex

Varies in:
- Thickness
- Texture
- Color (pigments)

- Distribution of the cortex is perhaps the most important component in determining from which individual a human hair may have come.

- Microscopic examination can also reveal the condition and shape of the root and tip.
Medulla

The medulla may vary in:

- **Thickness**
- **Continuity** - one continuous structure or broken into pieces
- **Opacity** - how much light is able to pass through it

- Medulla appearance may vary even within a person’s own hairs
Medulla Patterns

- Continuous
- Interrupted
- Fragmented
- None
Hair Structure

- Medulla: distinguish between hairs of different species, but not between hairs from different people.

- It may be absent in some species.

- Medullary Index: diameter of medulla relative to shaft
  - Humans: index < 1/3
  - Animals: Index ≥ 1/2
Hair color

- **Color:** mostly the result of **pigments**, which are chemical compounds that reflect certain wavelengths of visible light.

- **Main pigments:**
  - Eumelanin: brown or black hair
  - Pheomelanin: blonde or red hair

Treated Hair

• Dyeing hair: changes color of shaft

• Artificial bleaching: sharp distinction in the hair
  • Bleaching: Removes pigments and makes hair yellowish; makes hair brittle/disturbs scales

• Sun: more gradual
Hair Growth

• Grows at 0.44 mm/day.

• Colored Hair?
  • estimate when it was last dyed
    • Measuring the length of the hair that is naturally colored
    • Divided by 1.3 cm (1 month of growth)
Biology of Hair

- **Shape:** round or oval
- **Texture:** curly, straight, coiled
- Both are influenced heavily by genes.

- **Physical appearance:** can be affected by **nutritional** status and intentional **alteration** (heat curling, perms, straightening, etc.).

• 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 specific group.
Age and Sex Determination

- Cannot determine age of a person
  - May be able to distinguish infant from elderly for general age

- Long, treated hairs typically female, but otherwise, sex is difficult to determine… without DNA (stain for sex chromosome)

https://www.youtube.com/watch?v=3PBSQ3CqxUI&list=PLeHdnGTZyYCngJ2DkcUpXoQL9uDjm5fKA&index=46
Trace Evidence: Fibers

Becke Line

Forensic Science
Essential Questions – Day 2

- How is fiber evidence used in forensic science cases?
- What features distinguish hair and fibers? Natural and man-made fibers?
- How are hair and fibers discovered and processed at a crime scene?
Learning Targets – I can…

SFS2b-LK10: **Explain** how fibers are used as evidence

SFS2b-LK11: **Define** fiber, yarn, fabric

SFS2b-LK12: **Explain** cross-transfer

SFS2b-LK13: **Explain** the probative value of hairs and fibers

SFS2b-LK14: **Explain** the proper procedure for documenting and packaging hairs and fibers.

SFS2b- LR9: **Compare/contrast** hairs vs man-made fibers vs natural fibers

SFS2b- LR10: **Predict** the best method for analyzing fibers (including natural, man-made, regenerated) and **explain** distinguishing characteristics using that method

SFS2b- LS4: **Observe** fiber morphological and structural features using a compound microscope.

SFS2b- LS5: **Investigate** the identity of fibers using a burn test.
Fiber Evidence

Fiber: smallest unit of a textile material.
- length >100 times greater than its width.

Yarn: fibers spun together

Fabric: yarn is woven or knitted together

We shed a lot of fibers.

Fiber Evidence

• Matching **unique** fibers on the victim’s clothing to fibers on a suspect’s clothing? Helpful

• Matching **common** fibers such as white cotton or blue denim fibers? Less helpful.

• Note: Matching fibers from a suspect’s coat to fibers at the crime scene merely *suggests* a coat like the suspect’s was there…it does not prove that the suspect was there.

Transferring Fibers

- **cross-transfers** and multiple fiber transfers between the *suspect's* clothing and the *victim's* clothing dramatically **increases** the likelihood that these two individuals had physical contact.
Fiber Evidence: Transfer

- **Direct transfer**: passing of evidence, such as a fiber, from victim to suspect or vice versa
- **Secondary transfer**: transfer of evidence, such as a fiber, from a source to a person, and then to another person.

Carpet => suspect => victim

Direct transfer  Secondary transfer
direct transfer or primary transfer

indirect transfer or secondary transfer

indirect transfer or tertiary transfer

direct inverse transfer

cross-transfer
Fiber Evidence

Transfer of fibers depends on:

- type and length of fiber
- type of spinning method
- type of fabric construction

All very important for fiber \textit{transfer} between a suspect and a victim during the commission of a crime.

Fibers: Natural and Manufactured

Cross-section of a fiber (SEM)

Cotton fiber

wool fiber

polyester fiber
Natural fibers: come from plants or animals; used in the production of fabric.

Cotton fibers are the plant fibers most commonly used in textile materials.

Most frequent animal fiber: wool.

Most common wool fibers: from sheep.

http://www.fireflydiapers.com/articles/diaperarticle_naturalfibersabsorb.htm
Natural Fibers

- Other animal fibers
  - sheep
  - goats
  - camels
  - llamas
  - alpaca
  - vicanas

- Fur fibers
  - Mink
  - rabbit
  - beaver
  - muskrat
Identification of natural fibers

- Microscopic comparison
  - Color
  - Morphology

Need sufficient number of points of comparison between suspect and fiber of interest
Manufactured/synthetic Fibers

> 1/2 fibers used in the production of textile materials are synthetic or man-made.

examples of manufactured fibers: nylon, rayon, and polyester

Cross-section of a man-made fiber

Fibers under a microscope
Manufactured Fibers

- **Regenerated fibers**: manufactured from natural raw materials (chemically-treated cellulose)

- **Synthetic fibers**: from petroleum products; non-cellulose

- **Monomer**: two or more atoms held together by a chemical bond; link to form polymers

- **Polymer**: long chains of repeating units; basic chemical substance of a synthetic fiber
Monomer vs Polymer
Identification and comparison of manufactured fibers

- Microscopic examination of fibers
  - diameter
  - length-wise striations (lined markings)
  - surface pitting from titanium dioxide
  - Color (specific dyes...chromatography!)
Identification/comparison manufactured fibers

- Chemical composition
  - belong to same broad class
- Biorefringence: double refraction of polarized light
  - Uses a polarizing microscope
  - Becke Line
  - Nondestructive
Identification and comparison of manufactured fibers

- Infrared Absorption
  - Fibers *selectively* absorb IR light in a characteristic pattern
  - Couples IR microspectrophotometer with a microscope
Usefulness of fiber as evidence?

- Class evidence
  - Cumulative effect
- Wayne Williams
Collection and Preservation: Hairs and Fibers

• usually not visible to the naked eye

• clothing stored in paper bags
  • separate bags to avoid cross-contamination

• car seats covered with polyethylene sheets
Collection and Preservation: Hairs and Fibers

- knife blades covered to protect adhering fibers
- adhesive lifts from bodies
- Single strands folded into paper