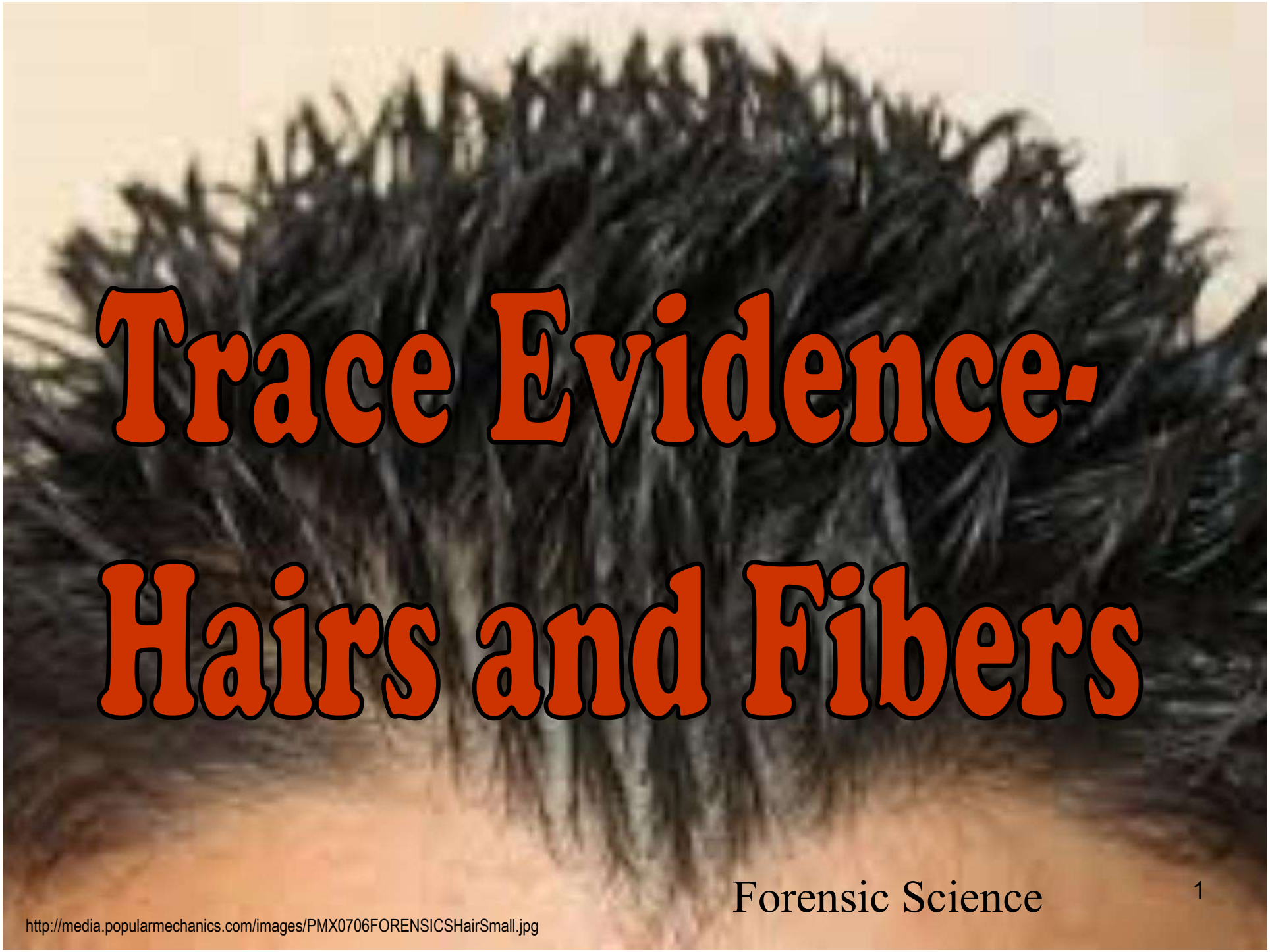


Trace Evidence- Hairs and Fibers

Forensic Science

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

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.

Standards

- 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."

Trace Evidence: Hair

- 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 vs Conclusive Evidence

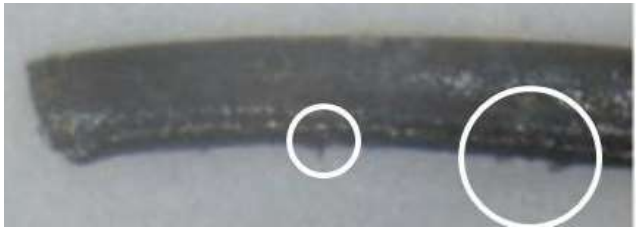
- Presumptive Evidence: does **NOT** provide ABSOLUTE proof for what the investigator is trying to determine

- Conclusive Evidence: good/hard proof for what the investigator is looking for

Trace Evidence: Hair

- can be determined by the sample's length, shape, size, color, and other physical characteristics.

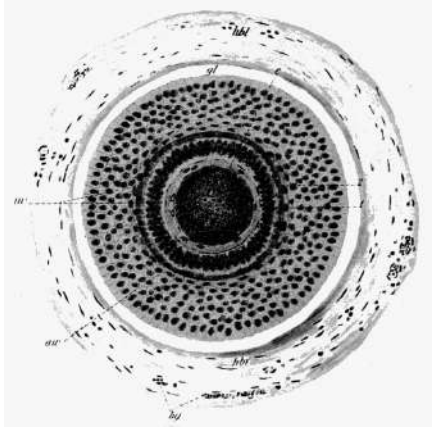
Tapered end



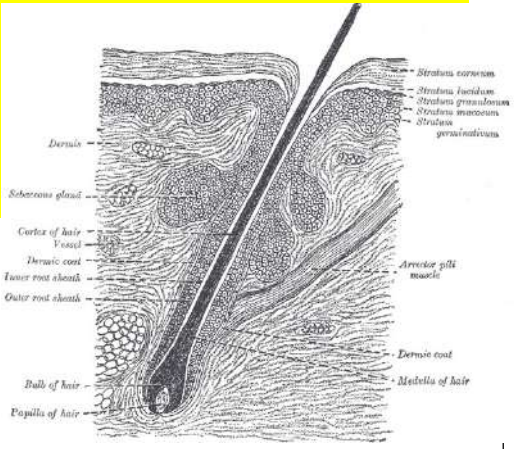
Blunt end
Circle area shows cuticle

Trace Evidence: Hair

- Six types distinguished by Forensic Scientists by looking at cross-sectional shape:
  - Head
  - Eyebrows/eyelashes
  - Beard and mustache
  - Underarm
  - Auxiliary or body
  - Pubic

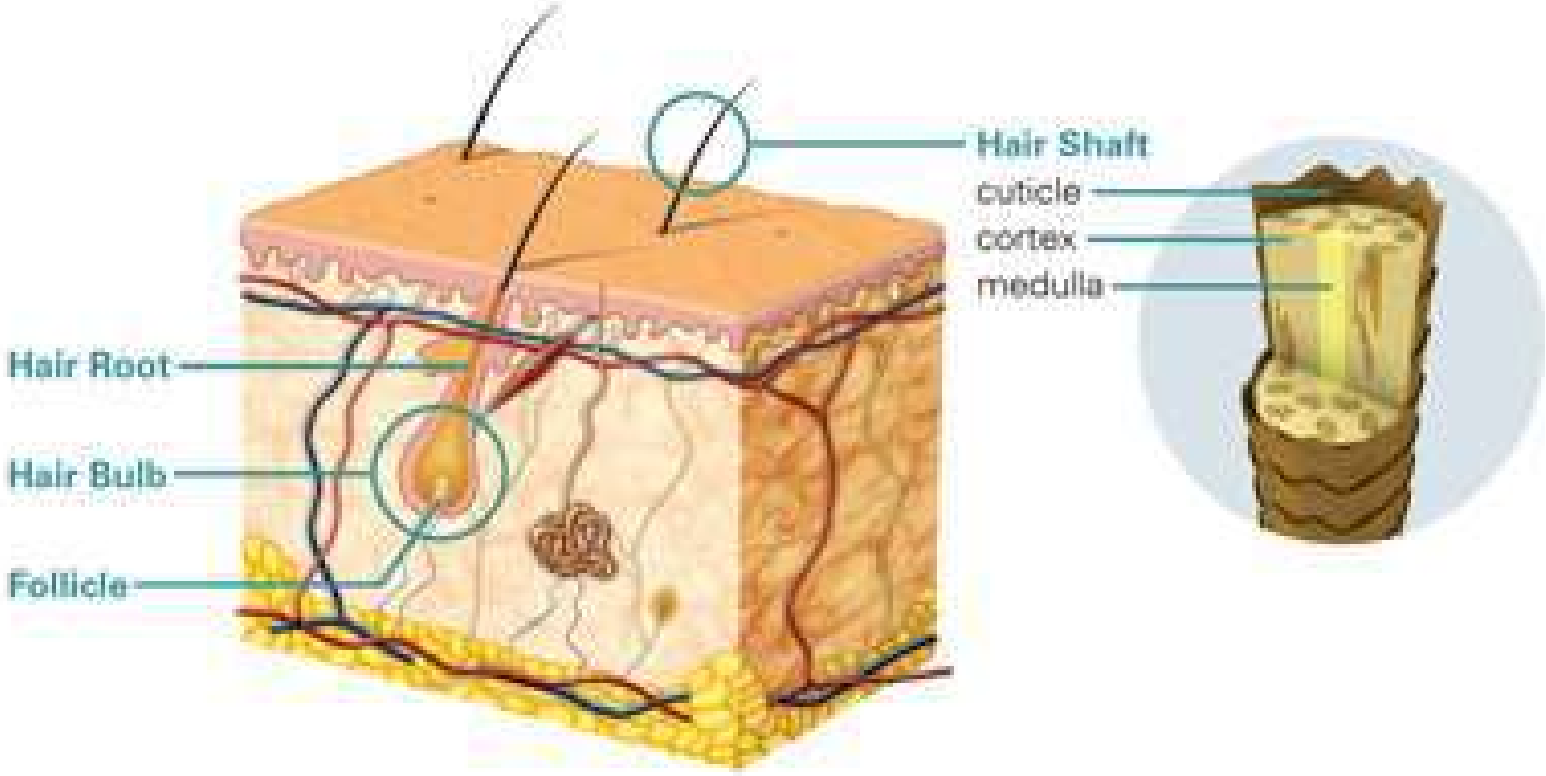


Biology of Hair



- 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

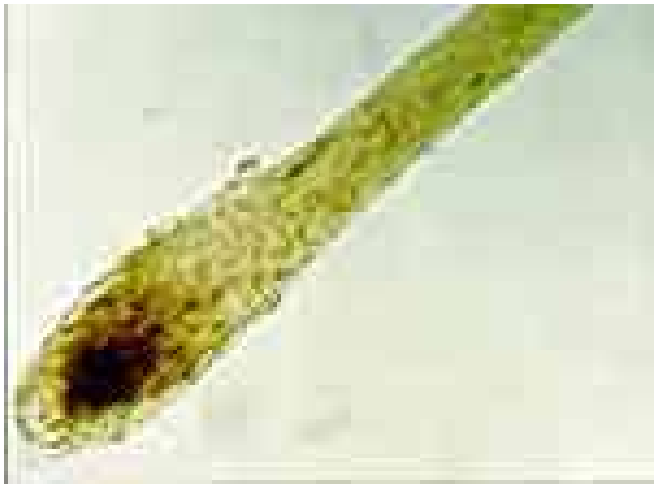
- **Bulb/root**: portion embedded in follicle
- **Shaft** of the hair extends out of the hair follicle
  - Terminates at the **tip end**
- In order to test hair evidence for DNA, the **root** must be present.

Phases of hair growth

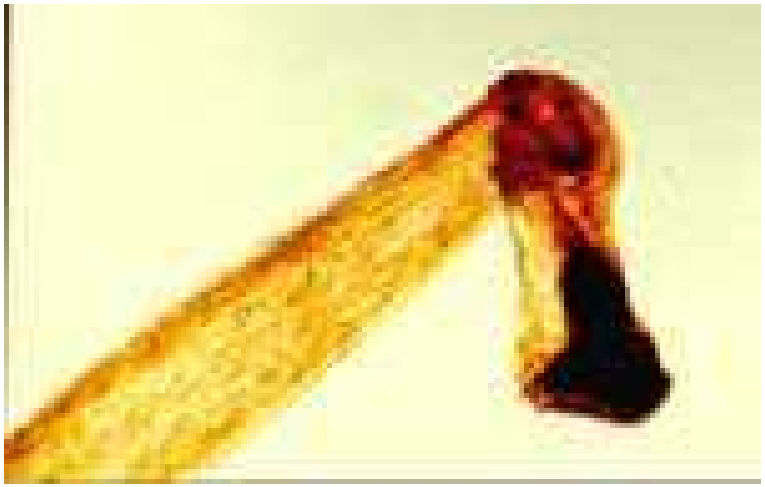
- Anagen : initial growth stage-follicle actively producing
  - May last up to 7 years
  - Some hairs have a follicular tag: contains the hair's nuclear DNA
  - 80-90% of head hair follicles in this stage
- Catagen: transition stage; roots are elongated and root shrinks
  - 2% of head hairs are in this 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)



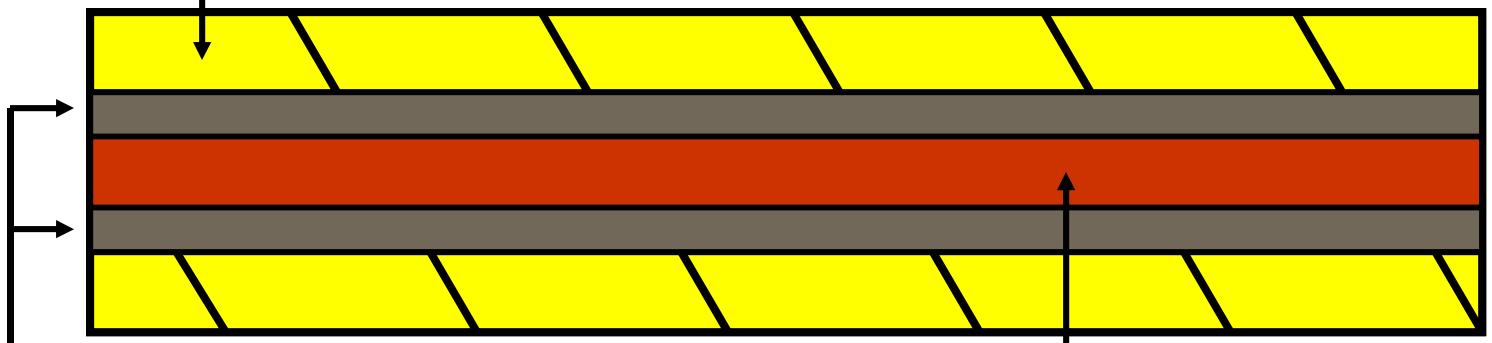
Pulled-out with force

Images from FBI.gov

Hair Structure

Hair is composed of three principal parts:

Cuticle – outer coating composed of overlapping scales



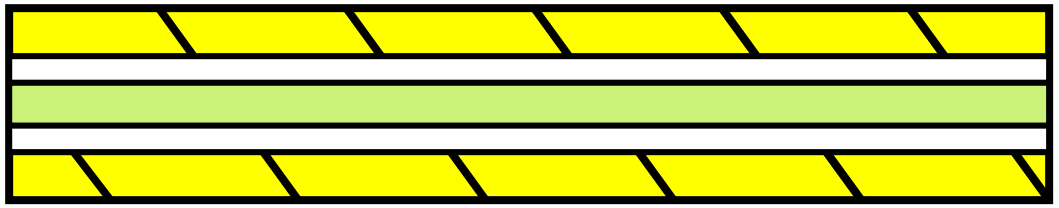
Cortex – protein-rich structure around the medulla that contains pigment, main body of the shaft

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

Hair Structure



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

Image: http://www.hairdressersus.com/micro/Image5b.jpg

Animal vs Human Hair

Spinous

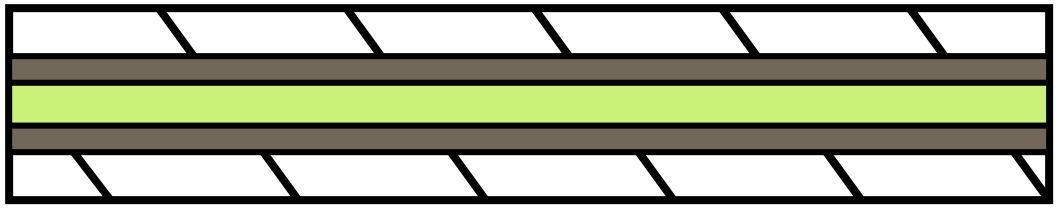
Coronal

Imbricate

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).

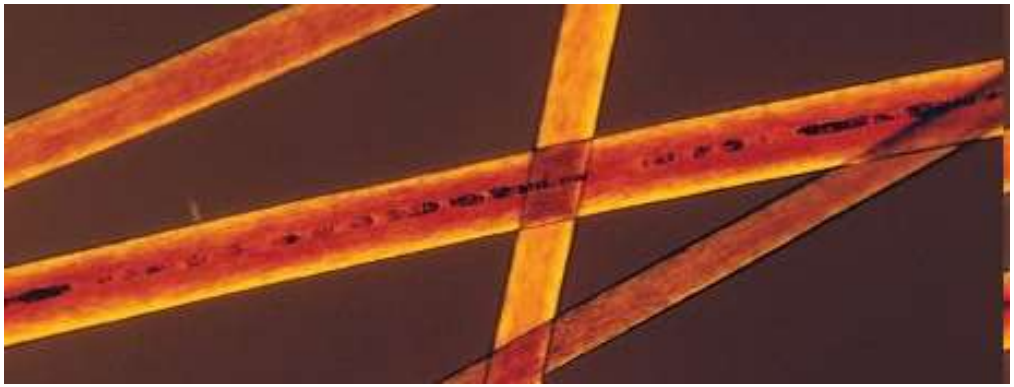
Hair Structure



Cortex

Varies in:

- **Thickness**
- **Texture**
- **Color (pigments)**



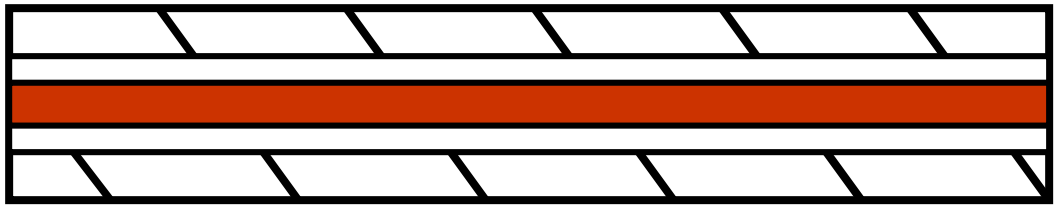
• Distribution of the cortex is perhaps the most important component in determining from which individual a **human** hair may have come.

• Microscopic examination can also reveal the condition and shape of the **root** and **tip**.

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

Image: http://www.extrapersonality.com/hair.html

Hair Structure



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

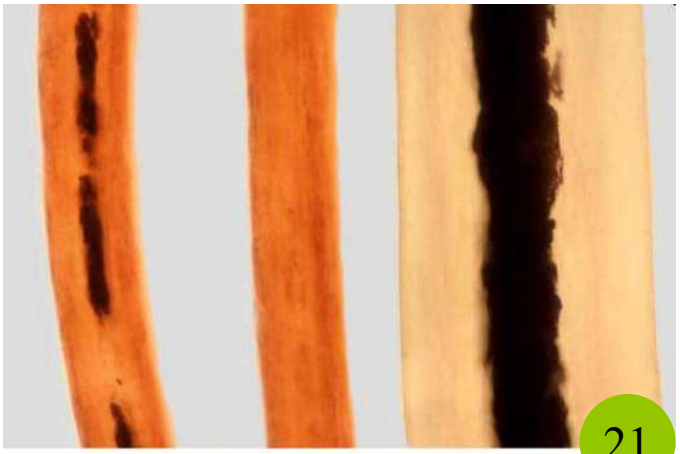


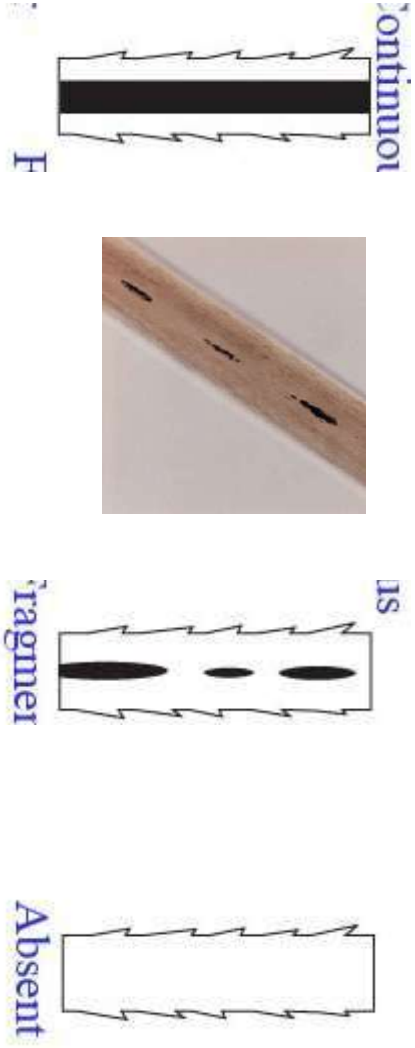
Figure 3. Light micrographs of three human hairs. The left example illustrates dark hair with a typical fragmentary medu
hair is blond and has no medulla. The right coarser hair is white with a continuous medulla.

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

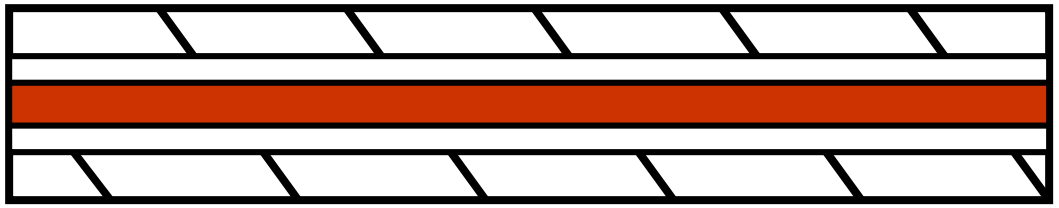
http://www.bfro.net/images/whatis/figures/Fig.%203%20with%20caption.jpg

Medulla Patterns

- Continuous
- Interrupted
- Fragmented
- None



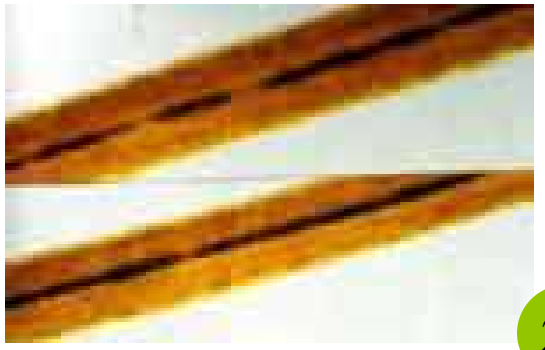
Hair Structure



- 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



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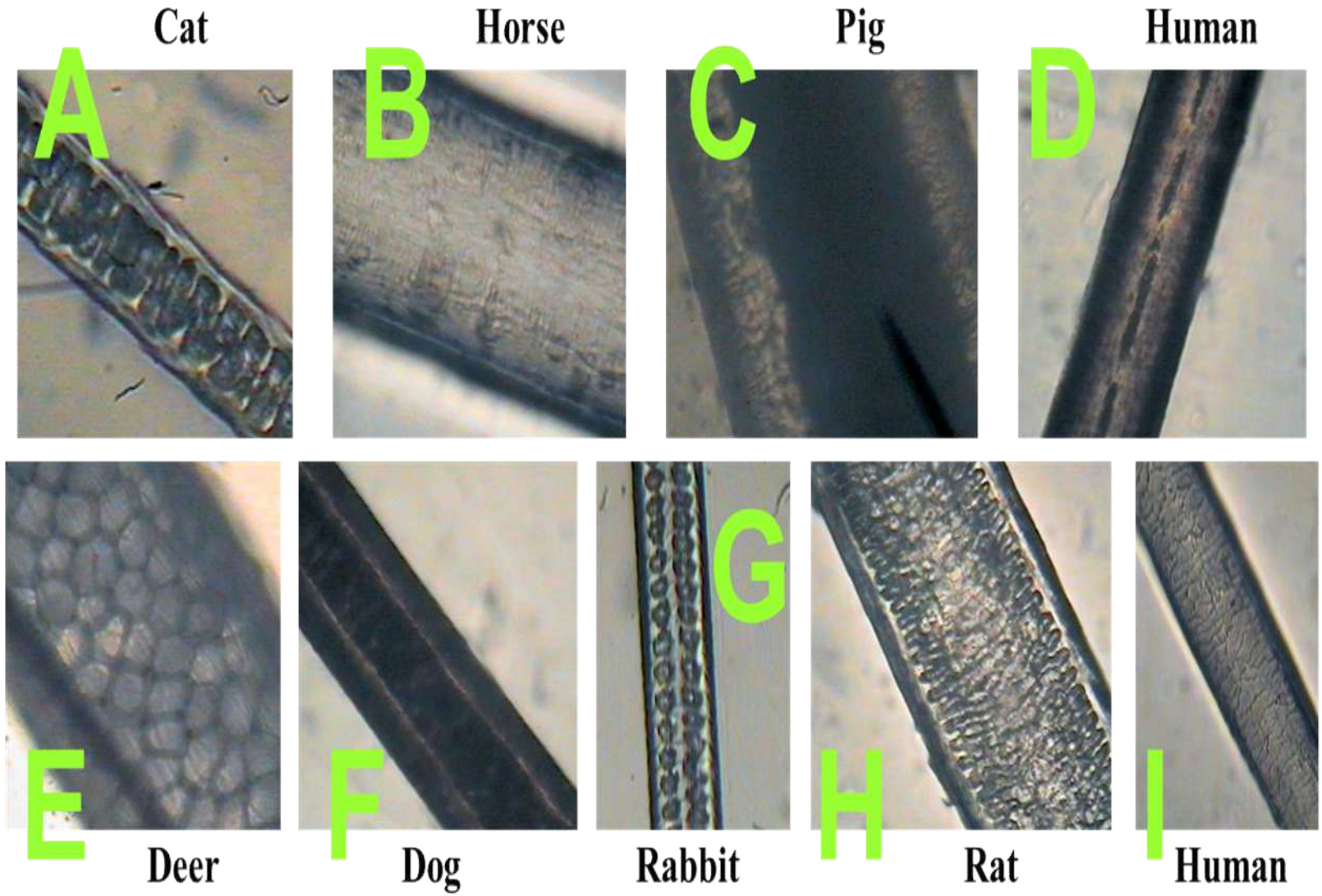
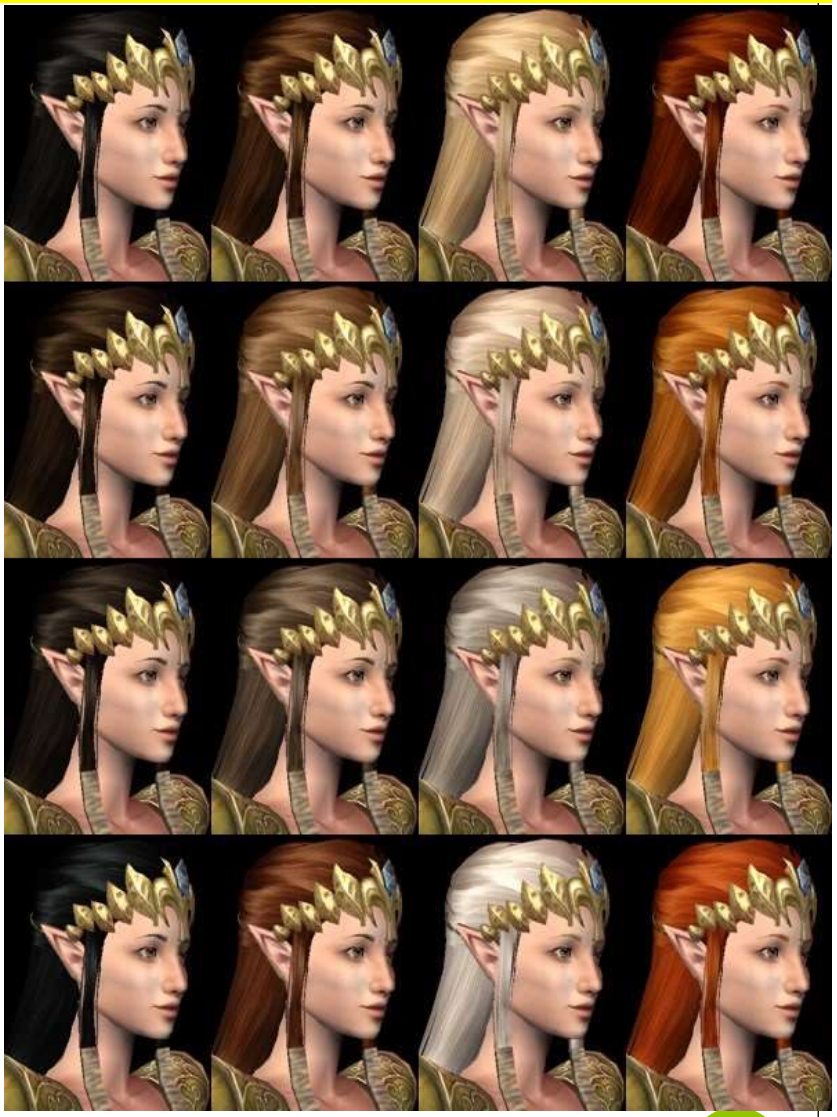

Cat
Horse
Pig
Human
A
B
C
D
E
F
G
H
I
Deer
Dog
Rabbit
Rat
Human

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



http://hat-plays-sims.dreamwidth.org/19547.html

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.).




Sources: http://library.thinkquest.org/04oct/00200/lesson.htm#t_hair & http://www.fbi.gov/hq/lab/fsc/backissu/july2000/deedric1.htm#Index%20(Hairs)

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 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

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

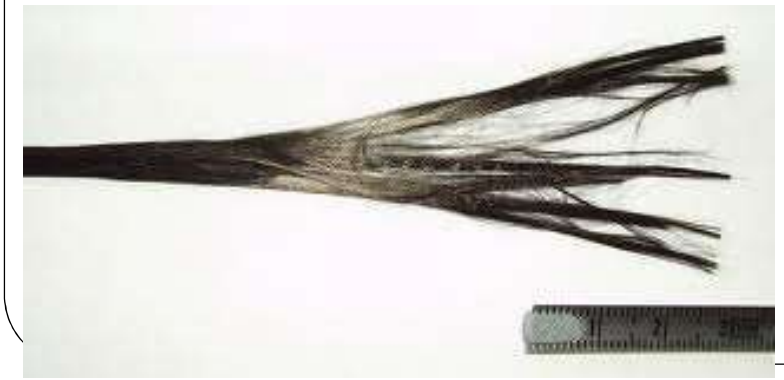
Fiber: smallest unit of a textile material.

- **length** >100 times greater than its **width**.

Yarn: fibers spun together

Fabric: yarn is woven or knitted together

We shed a lot of fibers.



http://www.fbi.gov/hq/lab/fsc/backissu/july2000/deedric3.htm#Fiber%20Evidence

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.

http://www.fbi.gov/hq/lab/fsc/backissu/july2000/deedric3.htm#Fiber%20Evidence

Transferring Fibers

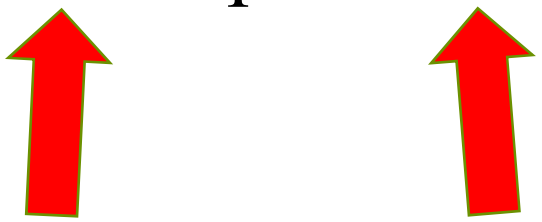
- **cross-transfers** and multiple fiber transfers between the *suspect's* clothing and the *victim's* clothing dramatically **increases** the likelihood that these two individuals had physical contact.

http://www.fbi.gov/hq/lab/fsc/backissu/july2000/deedric3.htm#Fiber%20Evidence

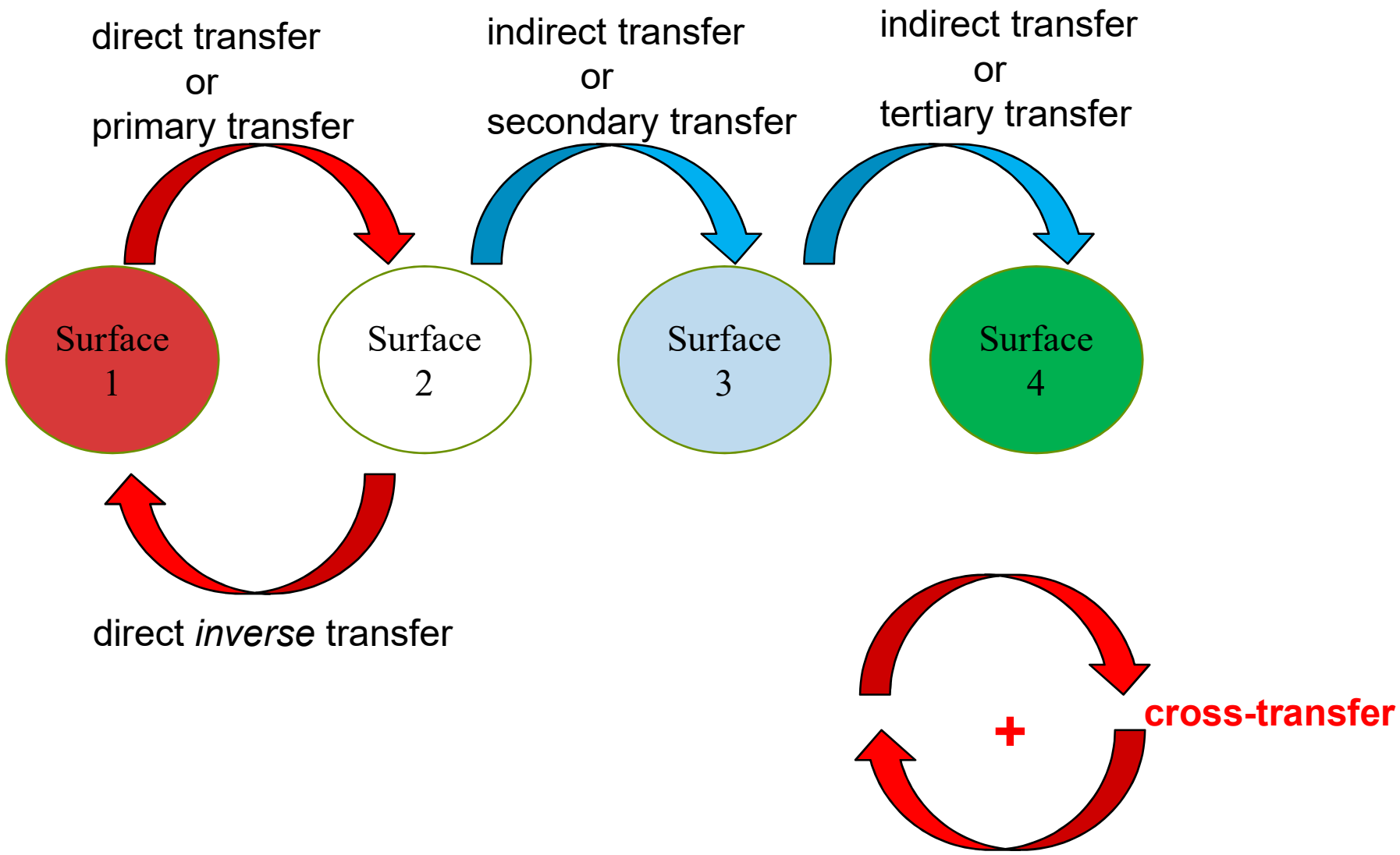
Fiber Evidence: Transfer

- **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
Surface
1
Surface
2
Surface
3
Surface
4
direct *inverse* transfer
+
cross-transfer

Fiber Evidence

Transfer of fibers depends on:

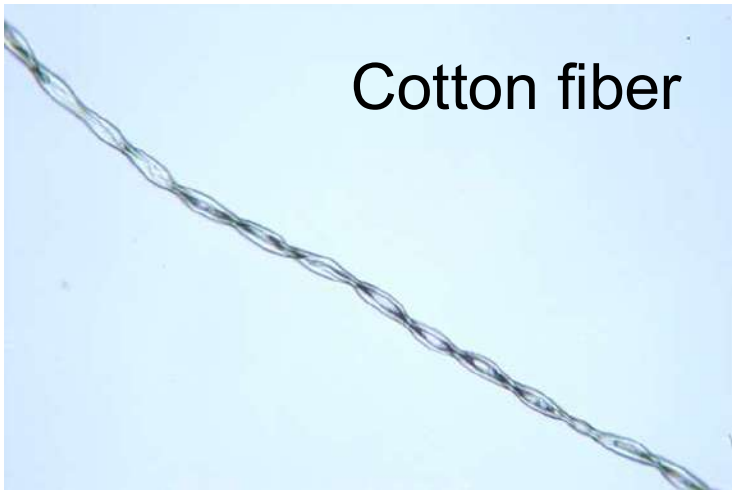
- type and length of fiber
- type of spinning method
- type of fabric construction

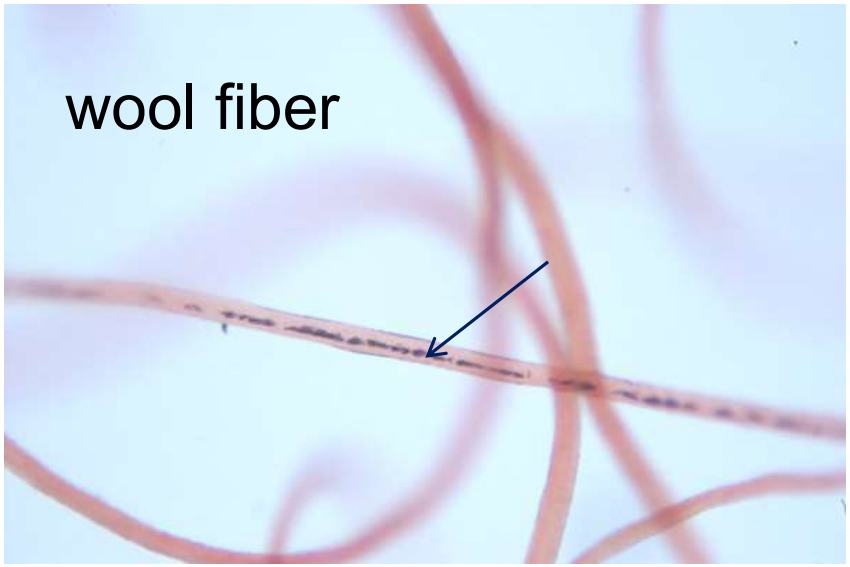
All very important for fiber **transfer** between a suspect and a victim during the commission of a crime.

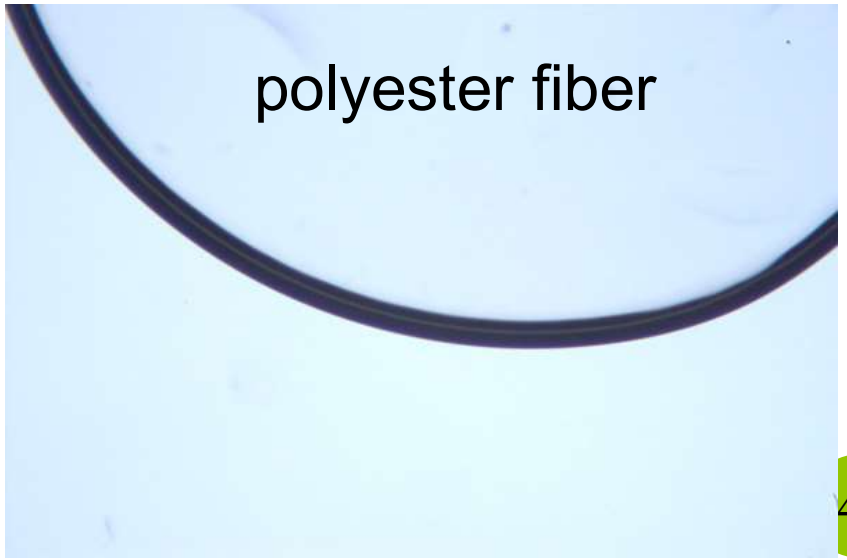
http://www.fbi.gov/hq/lab/fsc/backissu/july2000/deedric3.htm#Fiber%20Evidence

Fibers: Natural and Manufactured

Cross-section of a fiber (SEM)

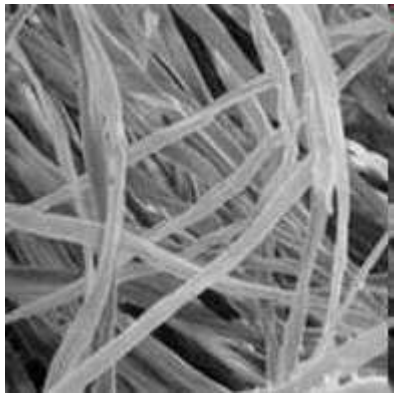






Natural Fibers

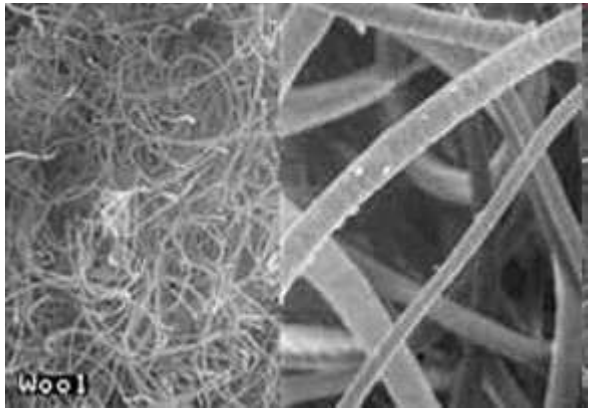
Natural fibers: come from plants or animals; used in the production of fabric.



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

Most frequent animal fiber: **wool**.

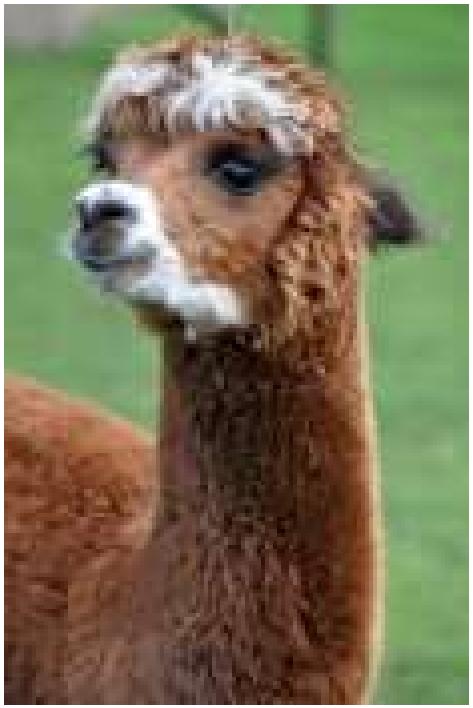
Most common wool fibers: from sheep



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

Natural Fibers

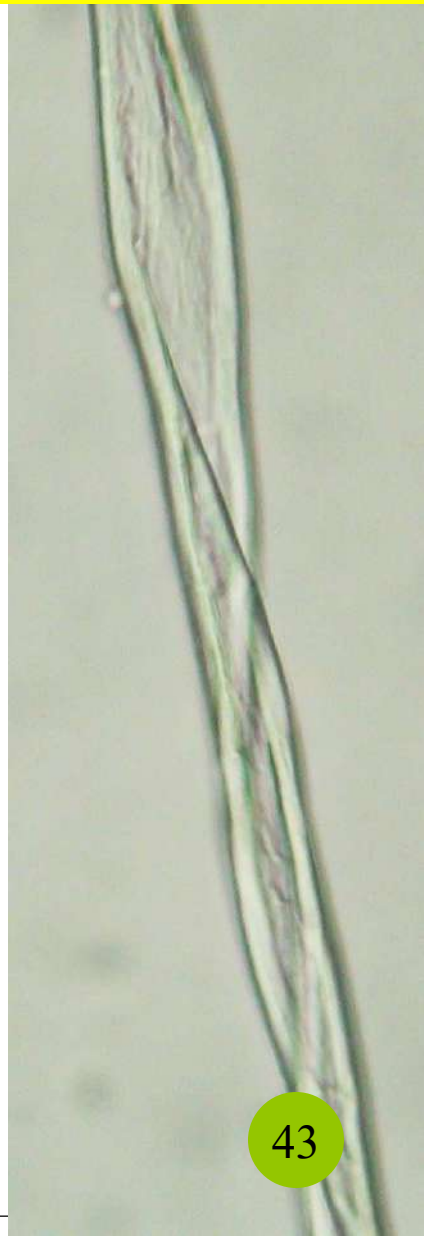
- Other animal fibers
  - sheep
  - goats
  - camels
  - llamas
  - alpaca
  - vicanas
- Fur fibers
  - Mink
  - rabbit
  - beaver
  - muskrat



Identification of natural fibers

- Microscopic comparison
  - Color
  - Morphology

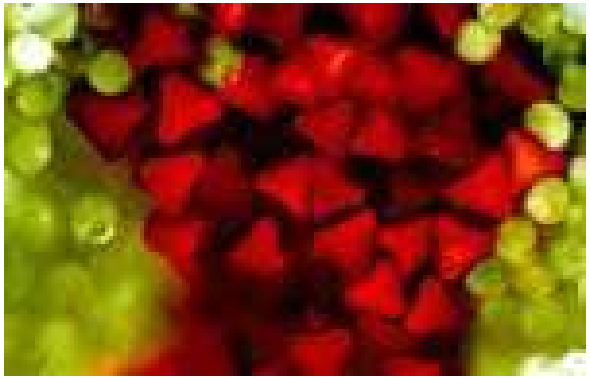
Need sufficient number of points of comparison between suspect and fiber of interest



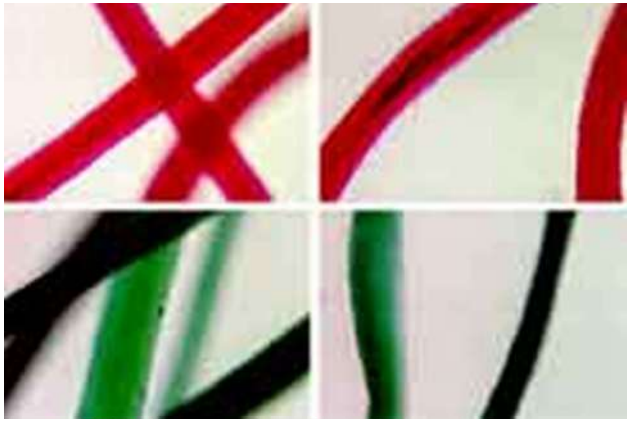
Manufactured/synthetic Fibers

> 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

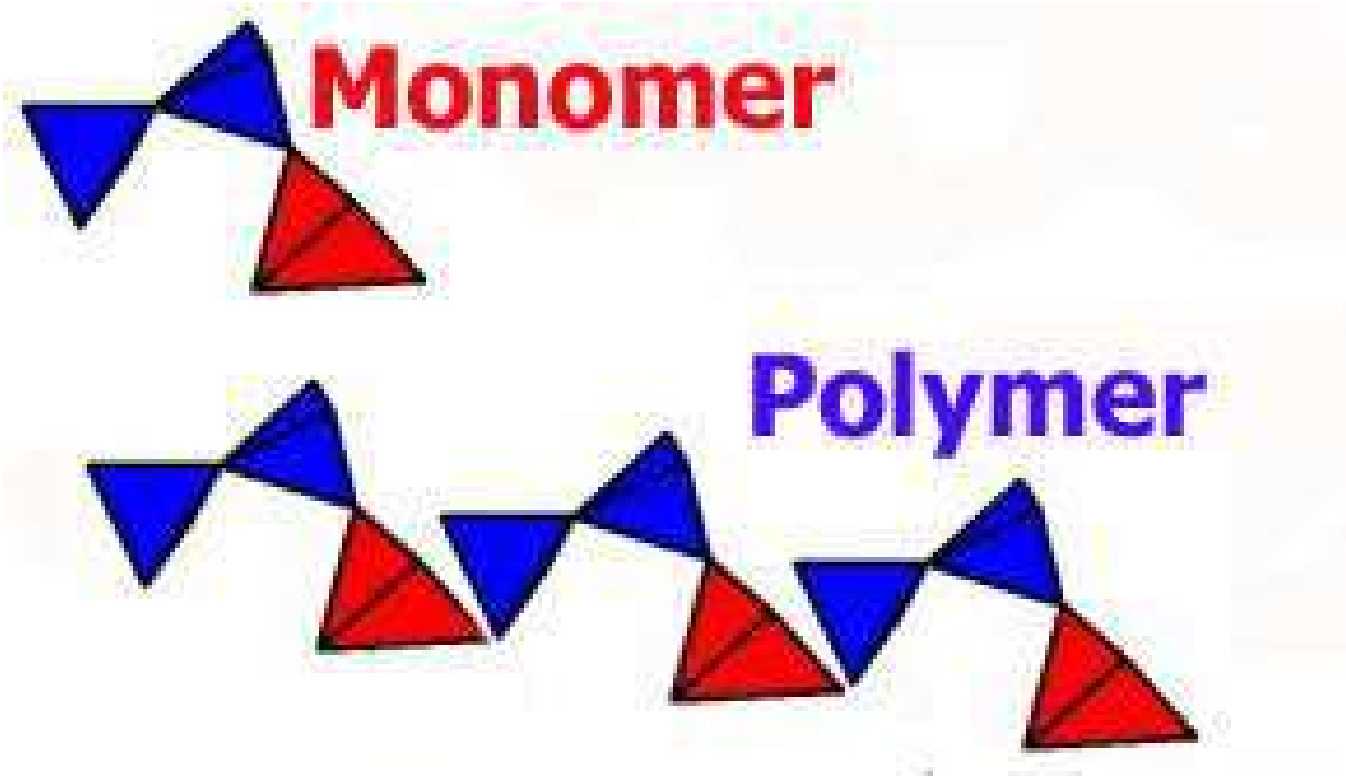


Fibers under a microscope

Manufactured Fibers

- **Regenerated fibers**: manufactured from natural raw materials (chemically-treated cellulose)
- **Synthetic fibers**: from petroleum products; non-cellulose
- **Monome**r: two or more atoms held together by a chemical bond; link to form polymers
- **Polyme**r: long chains of repeating units; basic chemical substance of a synthetic fiber

Monomer vs Polymer

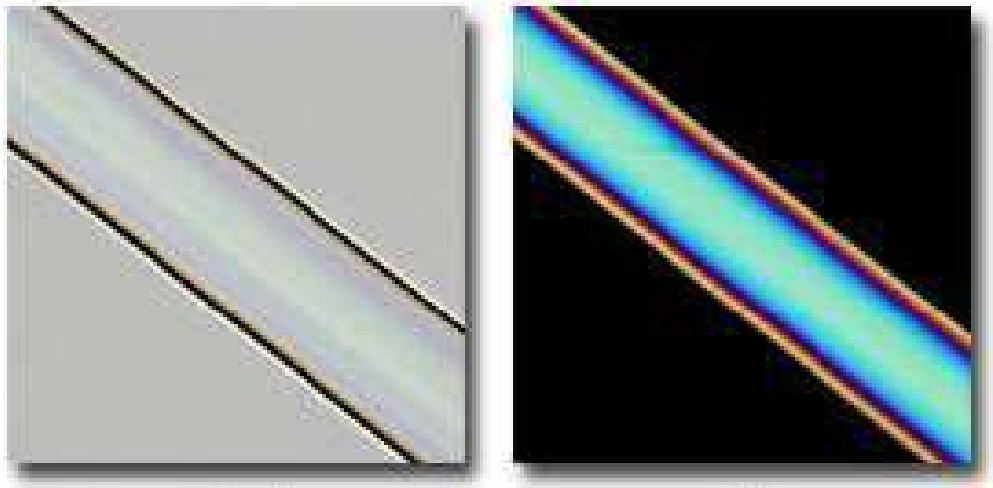


Identification and comparison of manufactured fibers

- 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