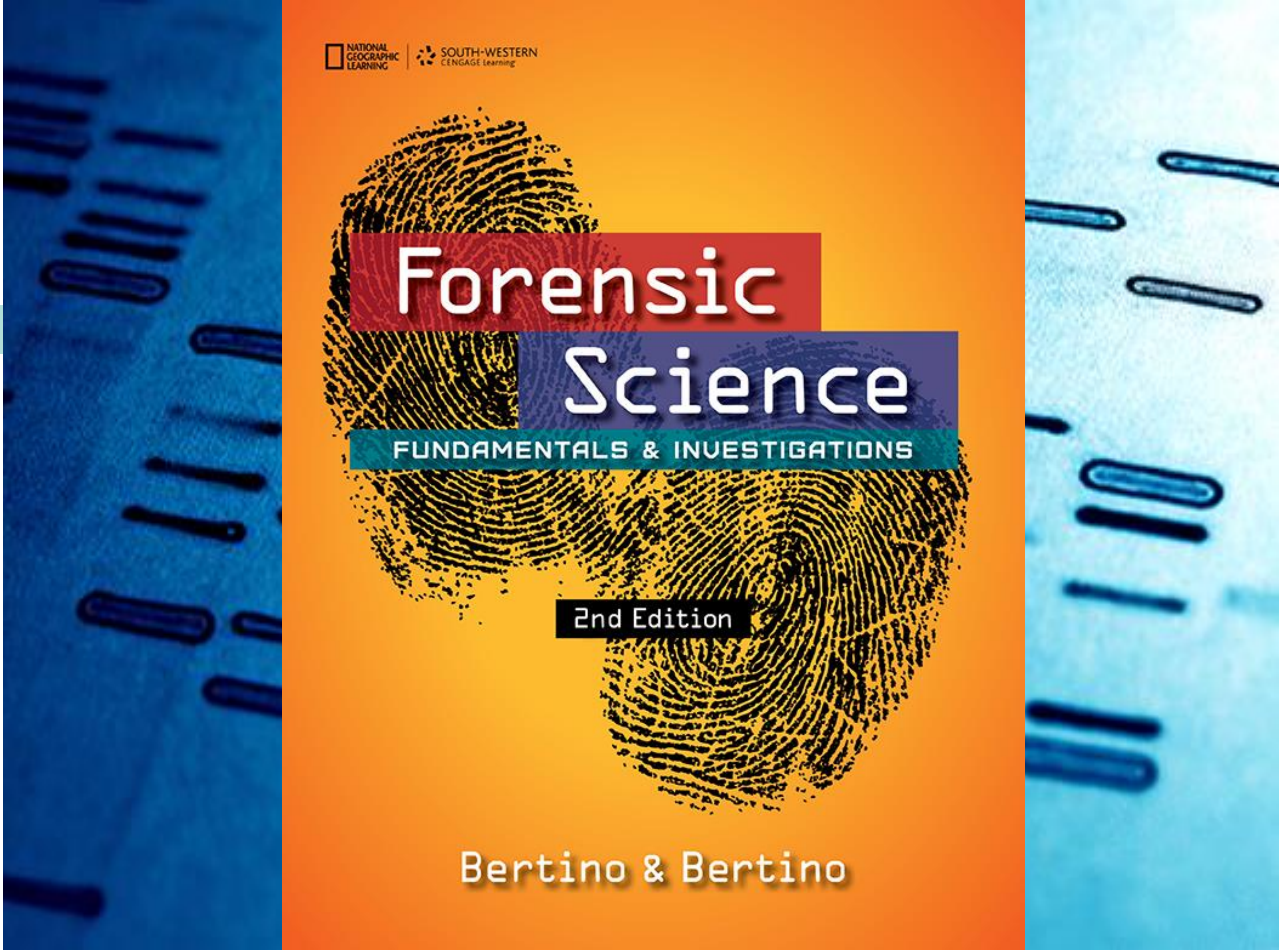

NATIONAL GEOGRAPHIC LEARNING
SOUTH-WESTERN
CENGAGE Learning
Forensic
Science
FUNDAMENTALS & INVESTIGATIONS
2nd Edition
Bertino & Bertino

- Csi case 2 http://forensics.rice.edu/
- Kahoot review https://play.kahoot.it/#/k/24e5ba4d-5553-44f6-9623-4ac1e4d6ec26
- FF northern exposure https://www.youtube.com/watch?v=mYtPJoxF0Wk
- FF conviction overturned with a hair https://www.youtube.com/watch?v=3JjevVi1ycU
- FF hair of the dog https://www.youtube.com/watch?v=uTdwo-RMF20
- FF beaten by a hair https://www.youtube.com/watch?v=0SKDCq4ojd8

Chapter 3 ***Hair Analysis***

By the end of this chapter you will be able to:

3.1 Identify the various parts of a hair.

3.2 Describe variations in the structure of the medulla, cortex, and cuticle.

3.3 Distinguish between human and nonhuman animal hair.

3.4 Determine if two examples of hair are likely to be from the same person.

Chapter 3 ***Hair Analysis***

By the end of this chapter you will be able to:

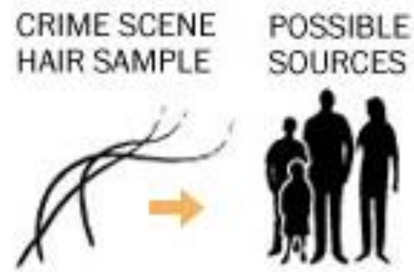
3.5 Explain how hair can be used in a forensic investigation.

3.6 Calculate the medullary index for a hair.

3.7 Distinguish hairs from individuals belonging to broad racial categories.

Chapter 3
Vocabulary

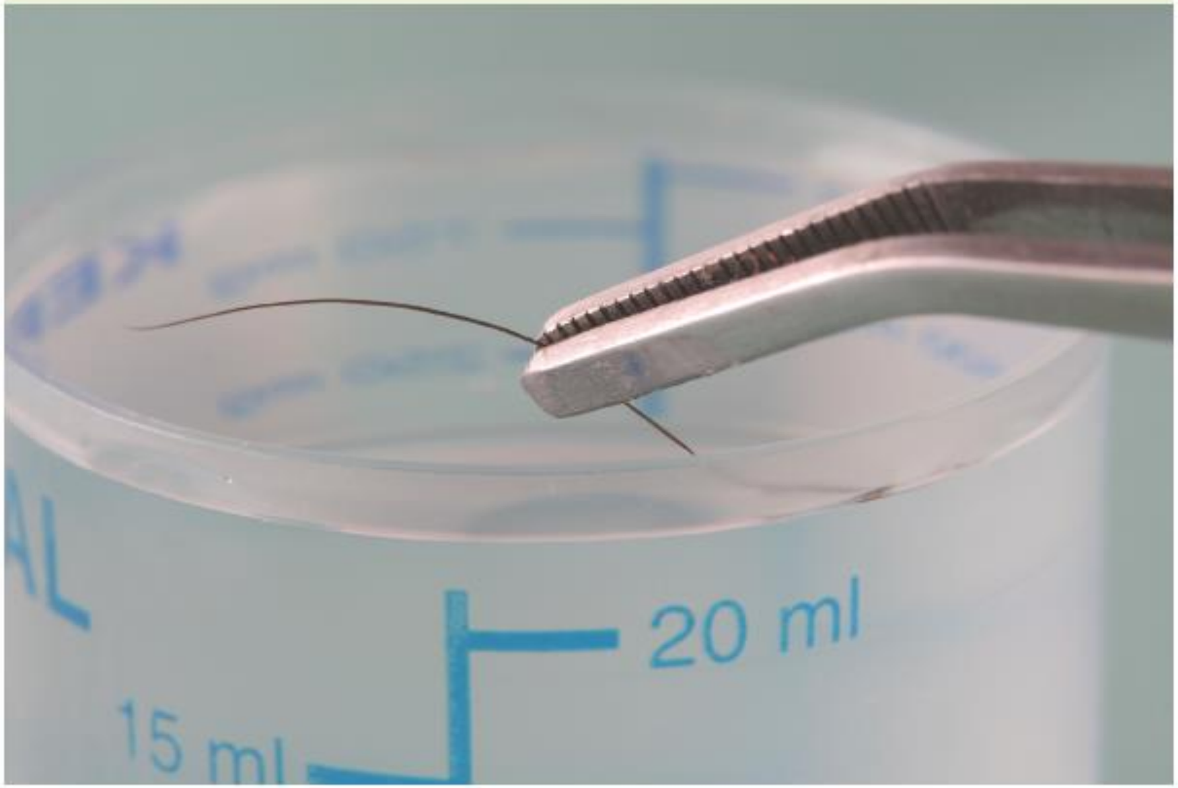
- comparison microscope
- cortex
- cuticle
- gas chromatography
- hair follicle
- hair shaft
- keratin
- medulla
- melanin granules
- mitochondrial DNA (mtDNA)
- nuclear DNA



I. Intro

- A. hair without the follicle and its nuclear DNA cannot be individual evidence.
  - 1. usually class evidence.
- B. Chemical tests: drugs, toxins, heavy metals and nutritional deficiencies.
- C. mtDNA (mitochondrial) :reveal family relationships.

Figure 3-1 *A forensic scientist prepares a hair for analysis.*



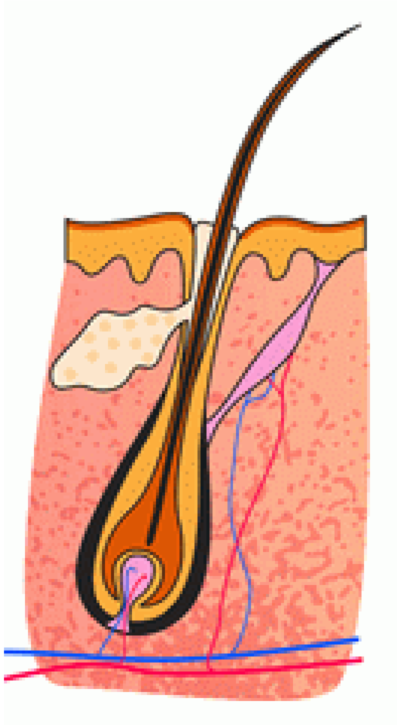
Ldf/Thinkstock/Getty Images

II. History

- A. 1883: Alfred Swaine Taylor and Thomas Stevenson covered hair in a forensic science text.
- B. 1910: Victor Balthazard and Marcelle Lambert published a comprehensive study of hair.
- C. 1934: Dr. Sydney Smith, analyzed hairs using comparison microscope.
- D. Today: analysis includes microscopic examination and DNA analysis.

III. Functions

- A. Regulates body temperature
- B. Decreases friction
- C. Protects against sunlight
- D. Acts as a sense organ
- E. camouflage



IV. Biology of Hair

A. composed of protein **keratin**

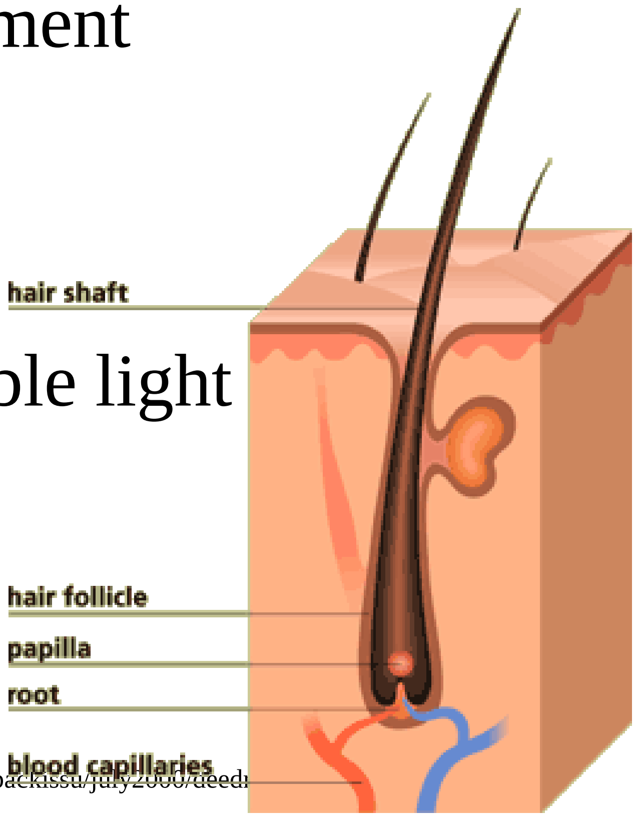
- 1. Also in finger /toe **nails**.

B. produced from hair **follicle**.

- 1. develop during **fetal** development
  - a. 5 million follicles
  - b. none produced after birth

C. Color- due to pigments

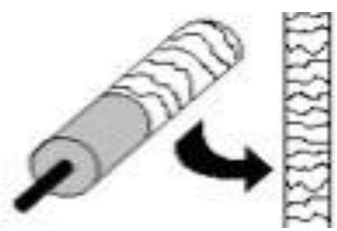
- 1. Reflect wavelengths of visible light

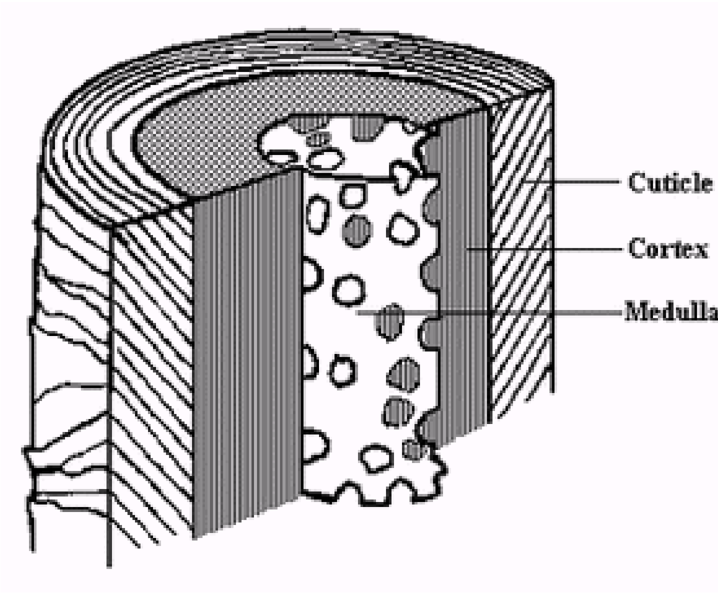


Sources: http://library.thinkquest.org/04oct/00206/lesson.htm#t_hair & http://www.fbi.gov/hq/lab/fsc/backissu/july2000/deedr

V. Structure of Hair

- A. Shaft
  - 1. Produced by follicle
  - 2. 3 layers:
    - a cortex (pigment)
    - b. medulla (core)
    - c. cuticle (outer)





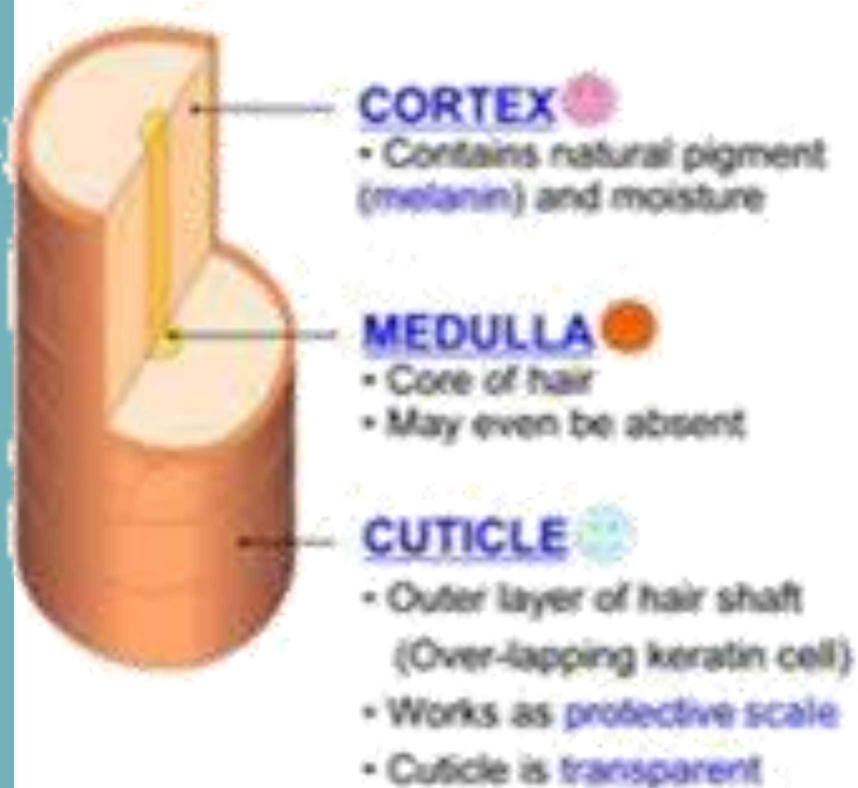
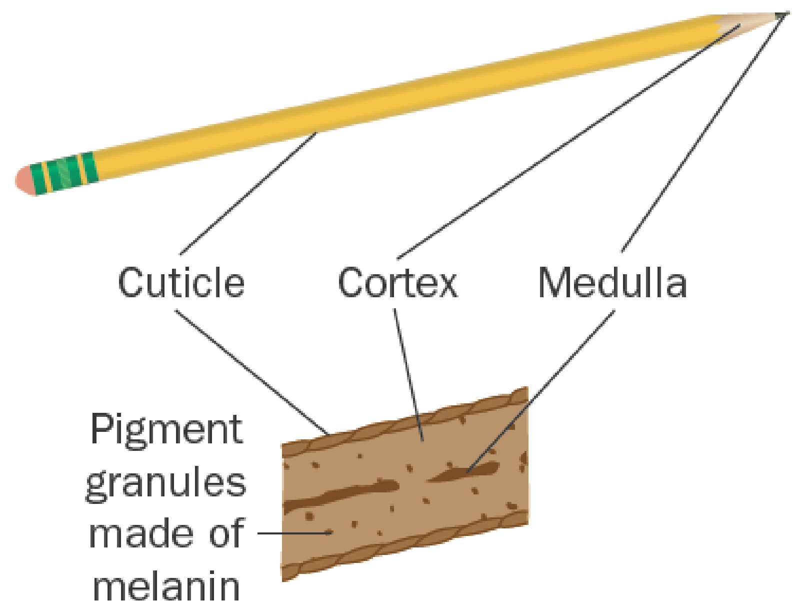


Figure 3-3 *The cross section of a hair shaft is similar to that of a round, wooden pencil.*



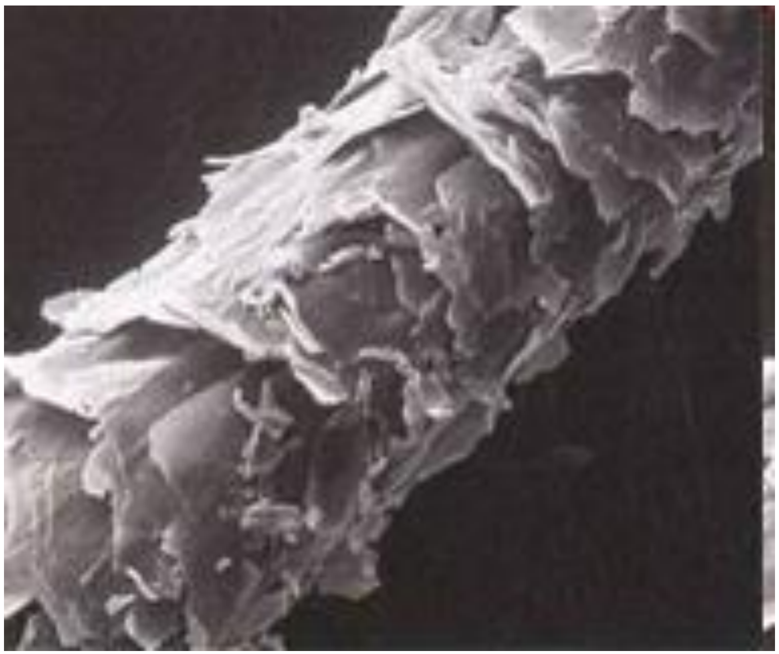
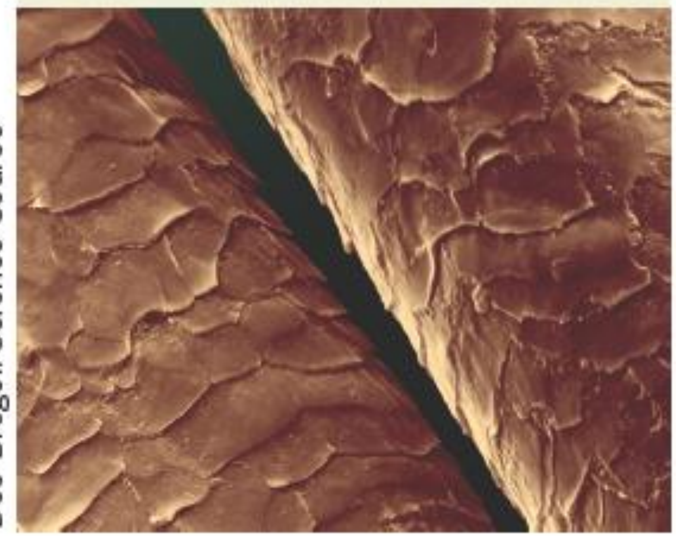


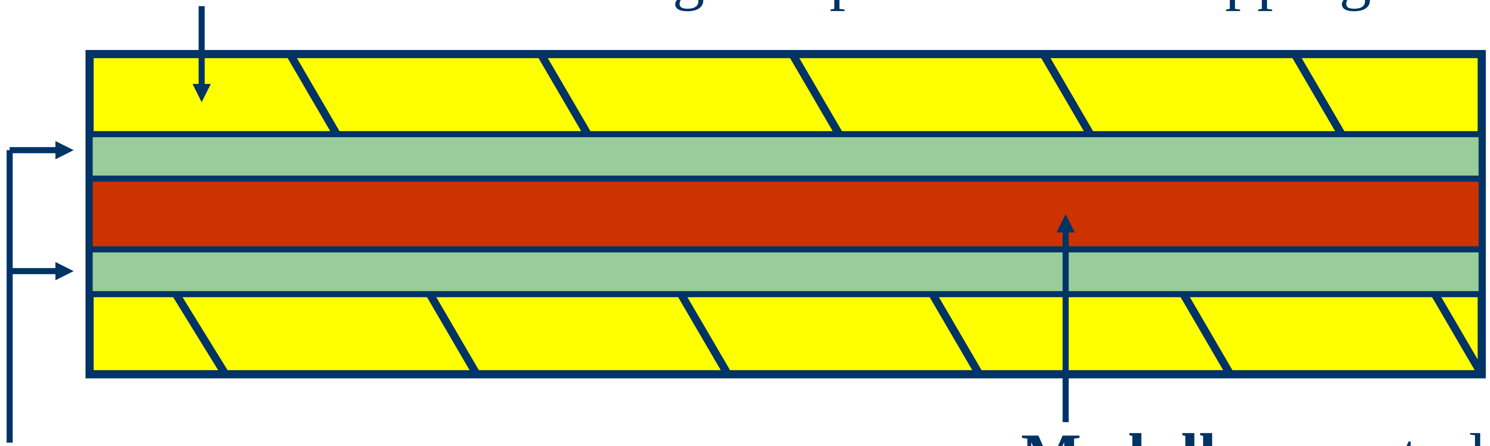
Figure 3-4 *This scanning electron photomicrograph shows the cuticle of a human hair with the overlapping (imbricate) scales.*



Dee Breger/Science Source

Hair Structure

Cuticle – outer coating composed of overlapping scales



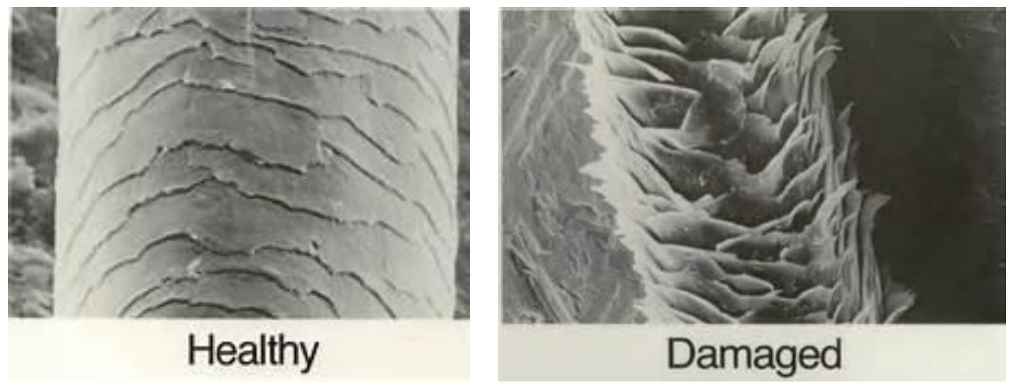
Cortex – protein-rich structure around the medulla that contains pigment

Medulla – central core (may be absent)

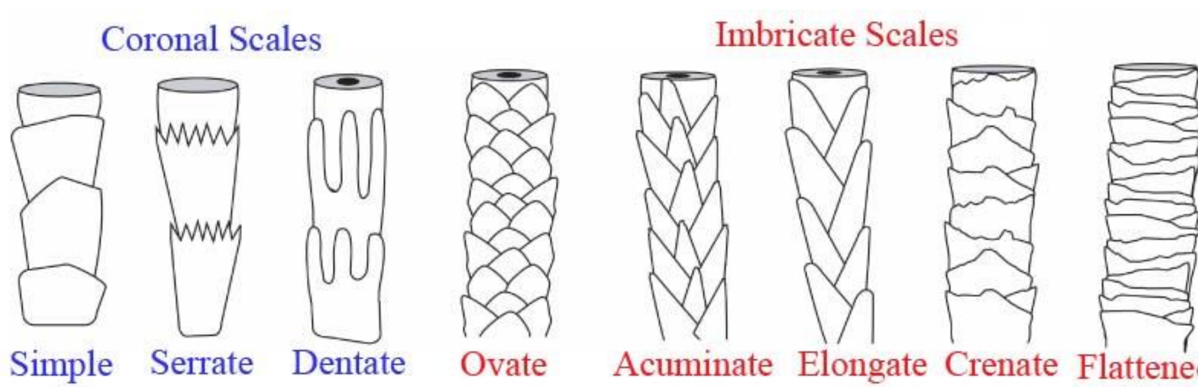
http://library.thinkquest.org/04oct/00206/lesson.htm#t_hair

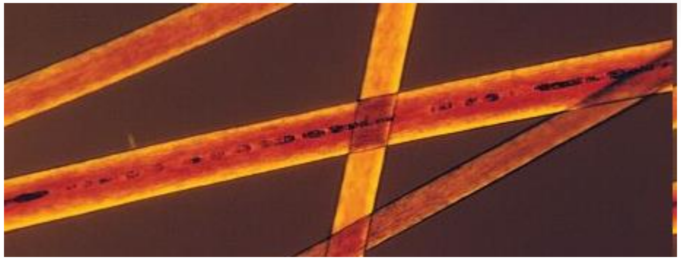
B. Cuticle

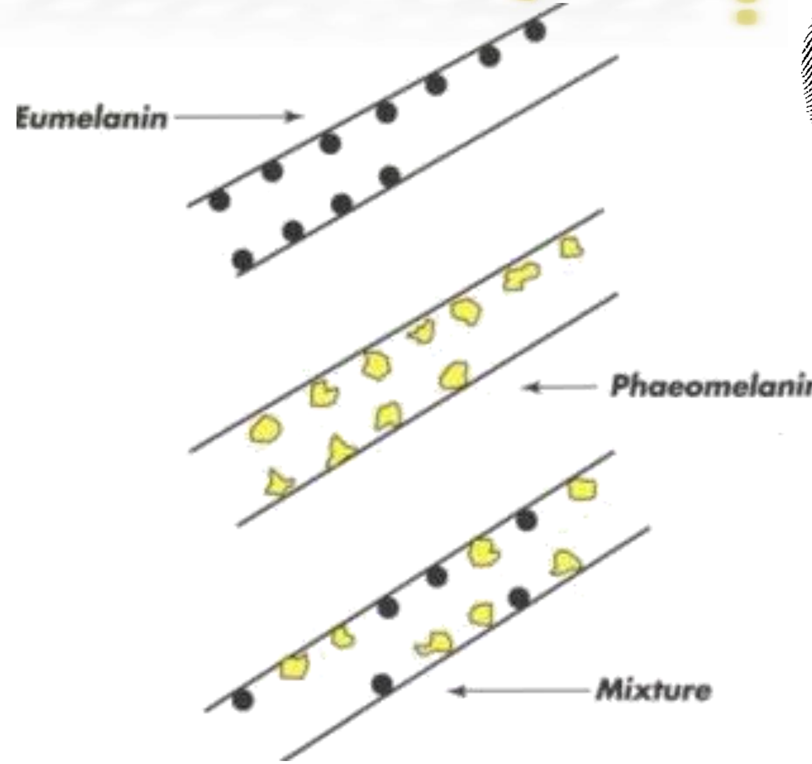
- **1.** **Transparent** outer layer ; **protects** .
- 2. **scales** that overlap one another and point toward the tip end



Different types of mammals have different cuticle scale patterns







C. Cortex:

1. middle layer
2. varies in:
   - a. **Thickness**
   - **b. Color (pigment)**
     - distribution varies person to person.
     - denser nearer the cuticle

- 3. cortex pigment is maybe the most important component in determining which individual a **human** hair may have come.

Info: http://library.thinkquest.org/04oct/00206/lesson.htm#t_hair Image: http://www.extrapersonality.com/hair.html

D. Medulla:

1. central core

a. hollow or filled

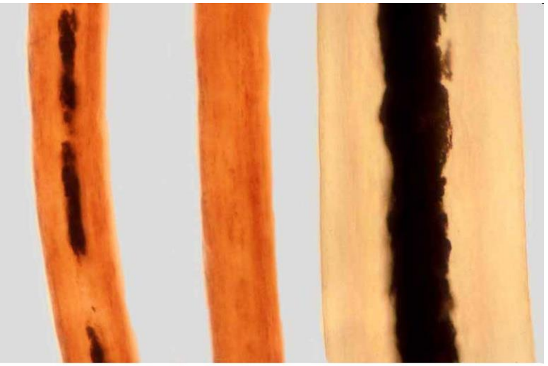


Figure 3. Light micrographs of three human hairs. The left example illustrates dark hair with a typical fragmentary medulla. The middle hair is blond and has no medulla. The right coarser hair is white with a continuous medulla.

b. vary in:

- **Thickness**
- **Continuity -** continuous or broken
- **Opacity -** how much light can pass through
- may be absent

medulla can be important for distinguishing between hairs of different **species**, but often does not lend much important information to the differentiation between hairs from different **people**.

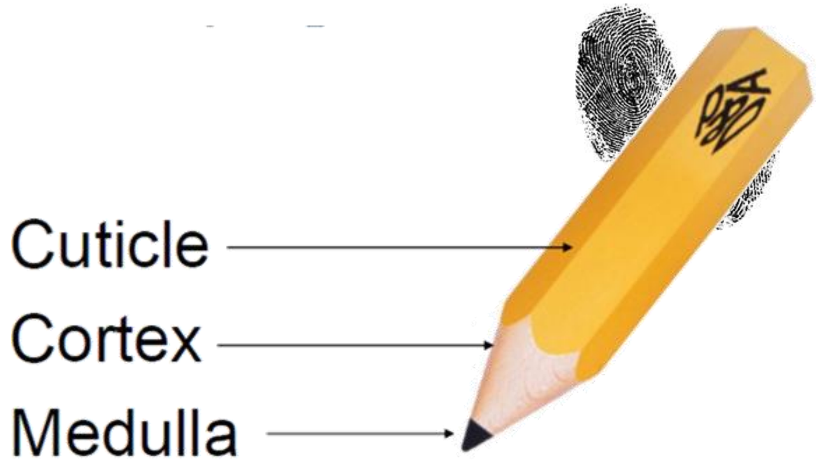
/lesson.htm#t_hair

2. 5 Types of Medulla

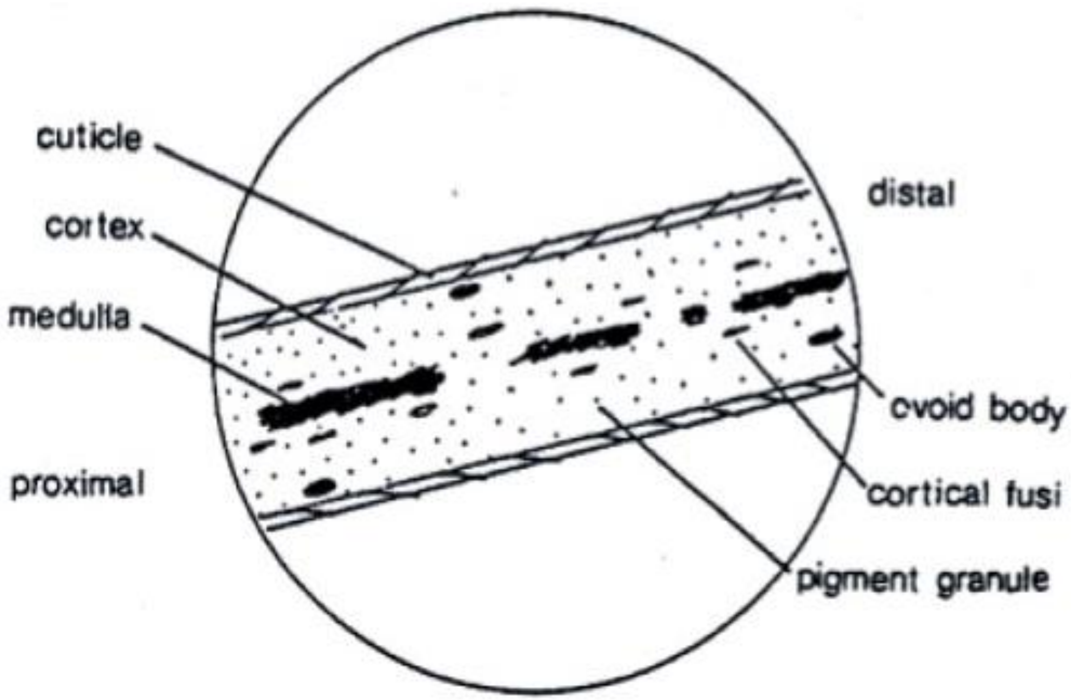
Figure 3-5 *Five different patterns of medulla pigmentation pattern are identified in forensic hair analysis.*

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	

Analogy for the structure of the hair shaft:



Good example of a microscope drawing of hair:

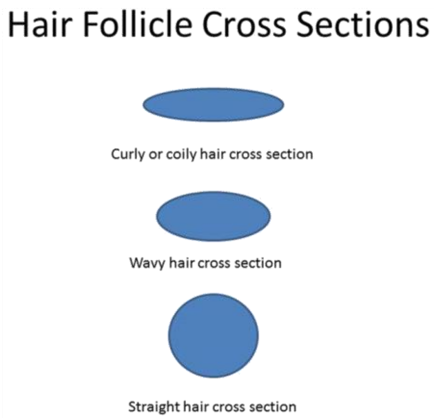


VI. Differences:

a. A. vary in shape, length, diameter, texture, and color. Need to collect at least 50 from head or 24 from pubic area

   a. 1. **cross section:** circular, triangular, irregular, or flattened, influencing the curl of the hair.

   b. 2. **texture:** coarse/ whiskers or fine/younger children.



Types of Hair

Buckled

Blunt

Double Medulla

- The cross section of a hair can be circular, triangular, irregular, or flattened influencing the curl
- The texture of a hair can be coarse or fine.
- To compensate for inconsistencies - 50 hairs collected from a suspect's or victim's head or 24 from pubic area

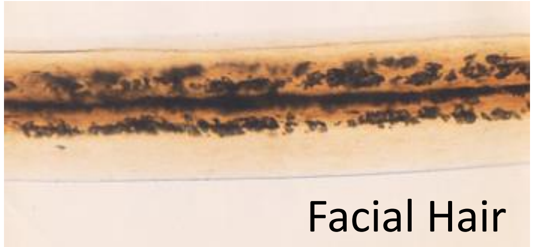
B. Differences can be used for identification (association) or **exclusion** in forensic investigations.

Hairs “could have a common origin”

Hairs “do not have a common origin”

C. 6 types of hair on body

- 1. **Head** hair
- 2. **Eyebrows** and **eyelashes**
- 3. **Beard** and mustache hair
- 4. **Underarm** hair
- 5. Auxiliary or **body** hair
- 6. **Pubic** hair



Facial Hair

Pubic Hair

Each hair type has its own shape and characteristics. ***

Hair from head and pubic region are the most **common** hairs found at crime scenes ***

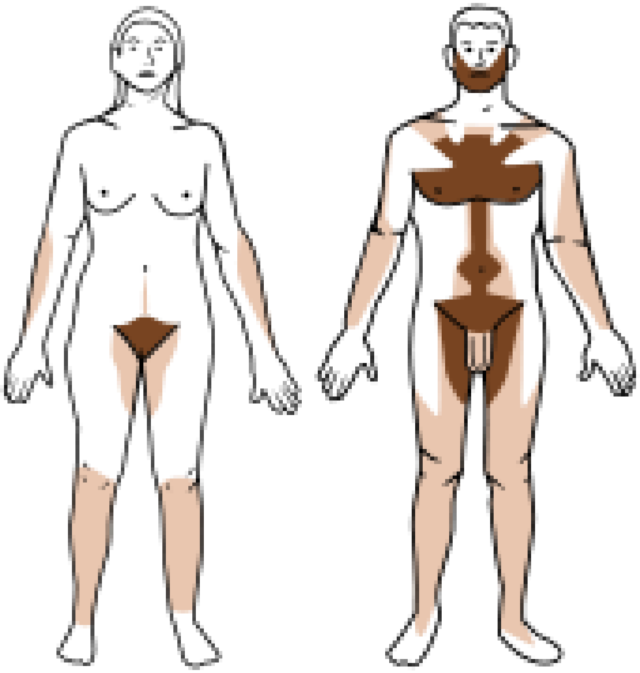


Figure 3-7 *The physical characteristics of a hair provide information about which part of the body it came from.*

Pubic hair showing buckling.

Beard hair with double medulla.

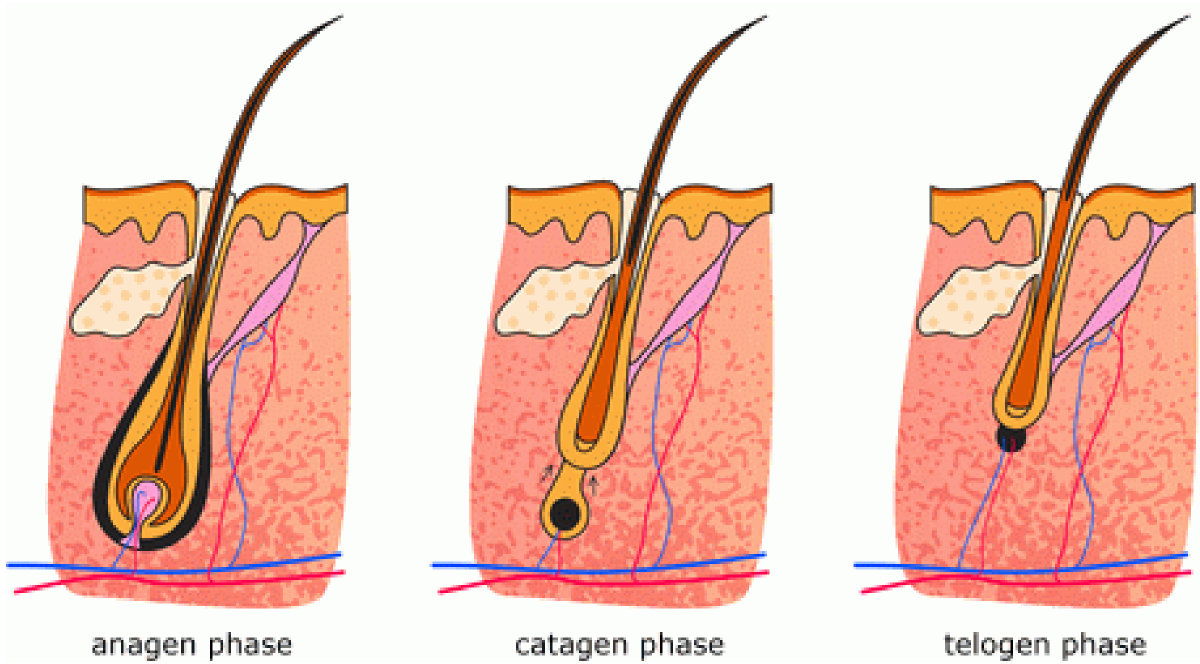
Arm or leg hair with blunt, frayed end.

Courtesy, FBI; photos by Sandra Koch & Douglas W. Deedrick

VII. Life Cycle

- A. three stages
  - 1. Anagen stage
    - Hair actively grows
    - Lasts approximately 1000 days
  - 2. Catagen stage
    - stops growing and the follicle recedes.
  - 3, Telogen stage
    - follicle is dormant and hair is easily lost.

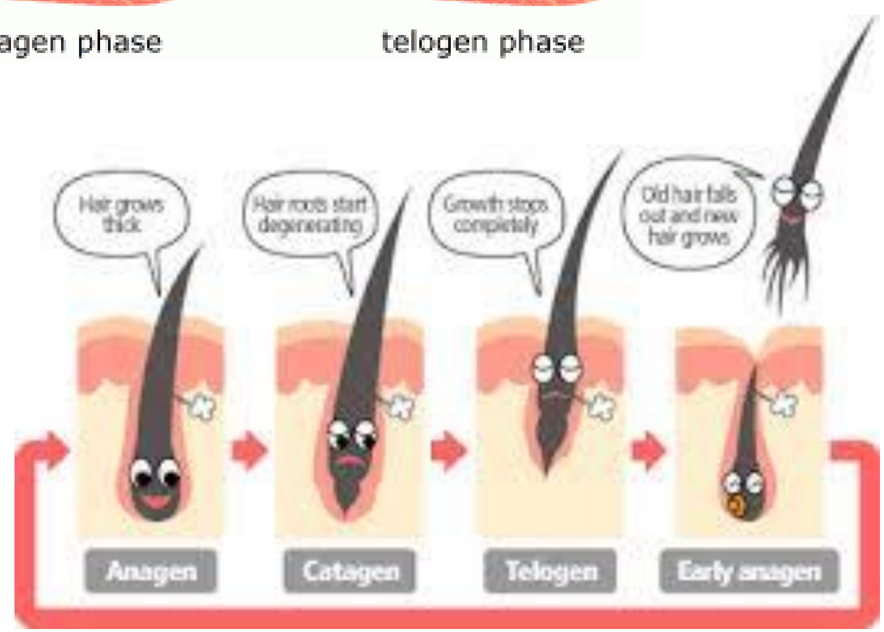
The Life Cycle of Hair



A= Period of active **growth**

C= Transitional or **regressive** stage

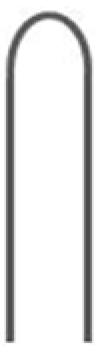
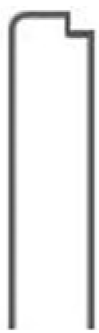
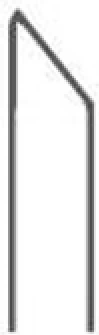
T= Final **resting** stage

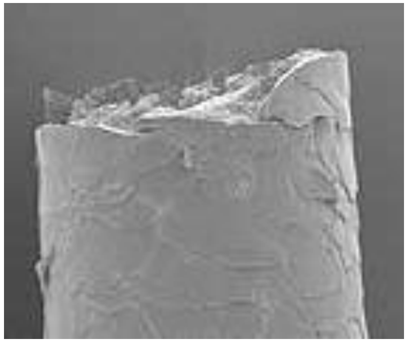


VIII. Distal Tips

- A. appearance of the tip of the shaft is an important **comparative** characteristic.
  - 1. may be possible to id type of treatment and estimate the length of time since the last cutting.

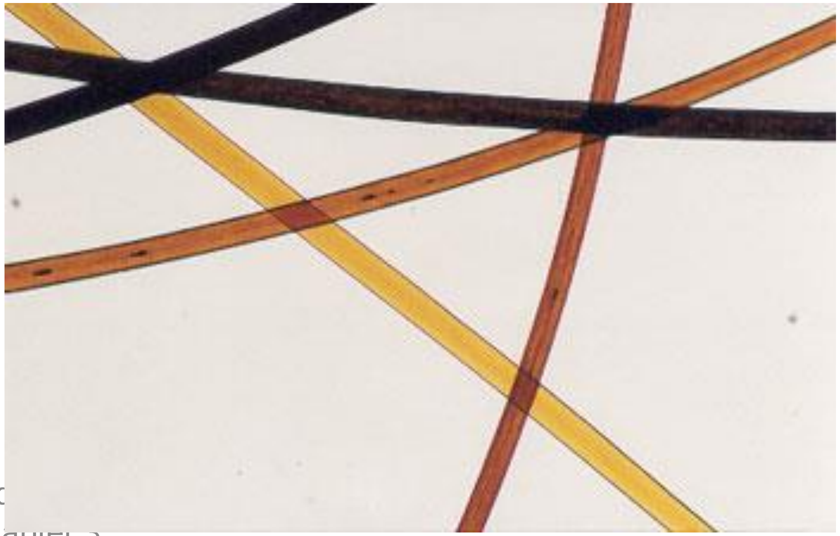
  2. Tips usually take on a rounded form in 2-3 **weeks**.

Uncut	Scissors (freshly cut)	Razor	Clippers
			
Tip is tapered, round, split, or frayed.	Tip is partially compressed.	Tip has a long tail on one side of the cut.	Reveals broken and partially cut shafts.



IX.Treated Hair

- A. Bleaching
  - disturbs the scales on the cuticle and
  - removes pigment
  - leaves hair brittle and yellowish
- B. Dyeing colors the cuticle and the cortex



Treated Hair

Figure 3-8 *Bleached hair lacks pigment in the cortex and cuticle.*

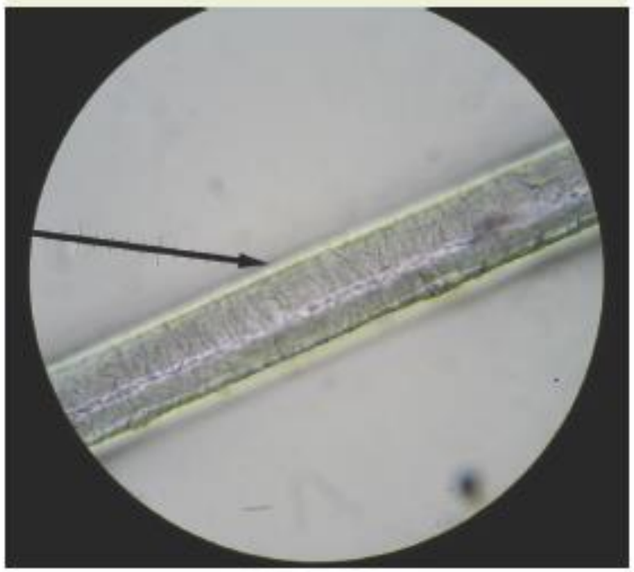
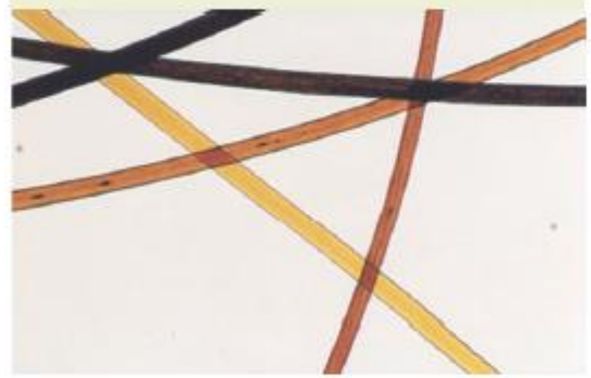


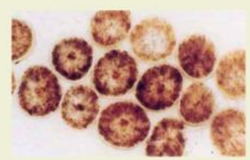
Figure 3-9 *Examples of dyed human hair. Notice the dye stains the entire hair, including the cuticle and cortex.*



X. Racial differences

- A. specific traits for racial groups based on established models- usually head hairs used

Figure 3-10 *A comparison of general characteristics of hair from people of different ancestries.*

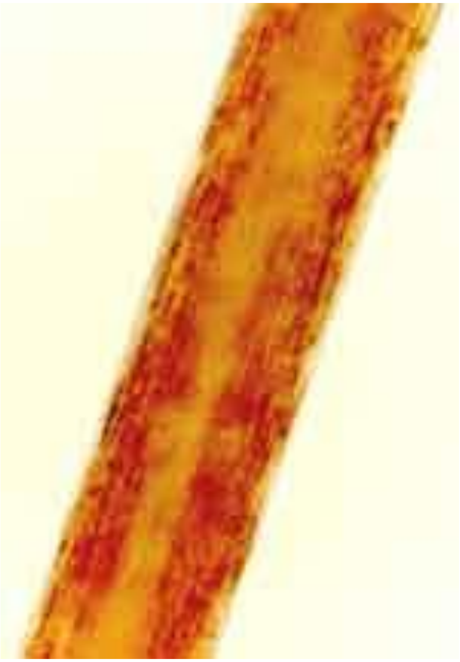
Ancestry	Appearance	Pigment Granules	Cross Section	Other
European	Generally straight or wavy 	Small and evenly distributed	Oval or round of moderate diameter with minimal variation 	Color may be blond, red, brown, or black
Asian	Straight 	Densely distributed	Round with large diameter 	Shaft tends to be coarse and straight; thick cuticle; continuous medulla; color black
African	Kinky, curly, or coiled; shaft may be buckled 	Densely distributed, clumped, may differ in size and shape	Flattened with moderate to small diameter and considerable variation 	

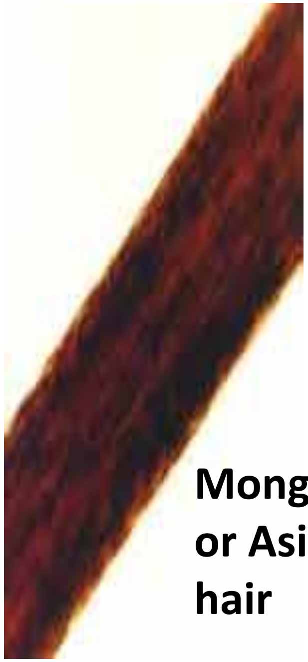
Courtesy, FBI; photos by Sandra Koch & Douglas W. Deedrick

Racial Differences

A human hair can be associated with a particular racial group based on established models for each group. Forensic examiners differentiate between hairs of **Caucasoid (European ancestry)**, **Mongoloid (Asian ancestry)**, **and Negroid (African ancestry) origin**, all of which exhibit microscopic characteristics that distinguish one racial group from another. Head hairs are generally considered best for determining race, although hairs from other body areas can be useful.

Caucasian or European hair



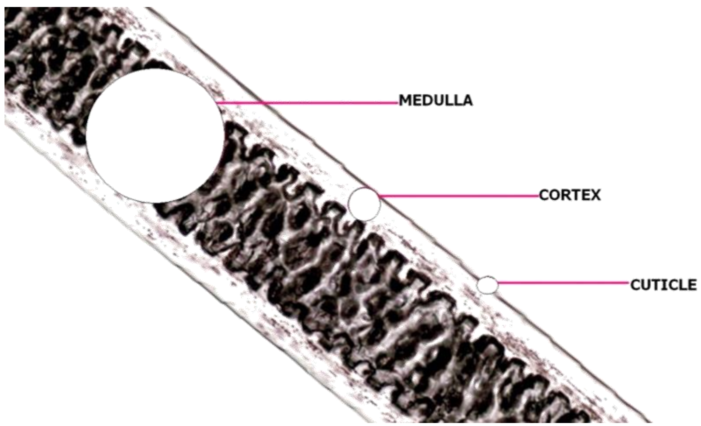


Mongoloid or Asian hair

Negroid or African hair

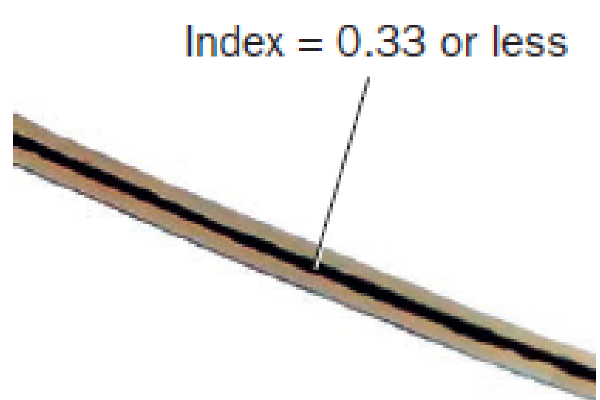
XI. Animal vs Human Hair

A. **calculate the medullary index**



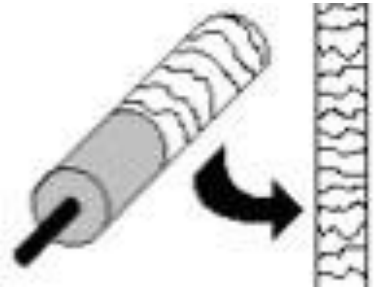
1. Diameter of the **medulla divided** by the diameter of the entire hair
   - a. greater than 0.5 = **animal**.
   - b. less than 0.33 = **human**.

Cattle hair



Human hair

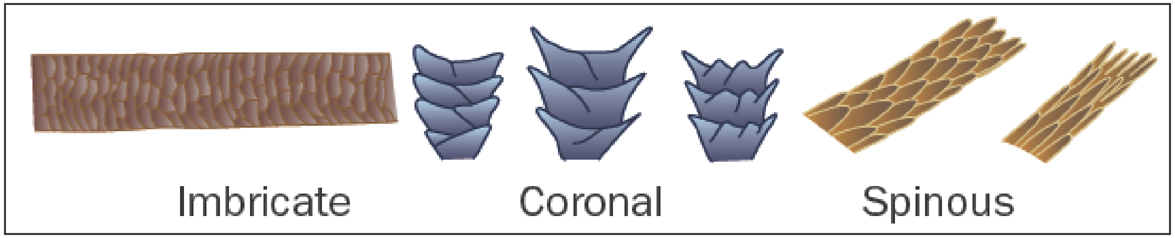
Animal vs Human Hair



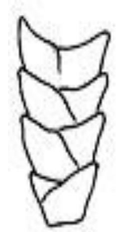
- B. Pigmentation:
  - Animal-denser toward the medulla
  - human -denser toward the cuticle
- C. Banded Color Patterns:
  - animals only not humans
- D. Medulla: thicker in animals

Animal vs human

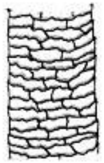
Figure 3-12 *Imbricate (human), coronal (mouse), and spinous (cat) cuticles.*



Spinous



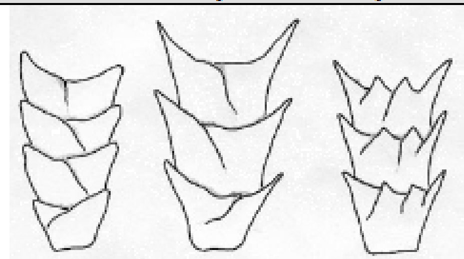
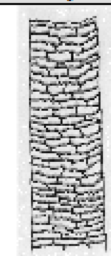
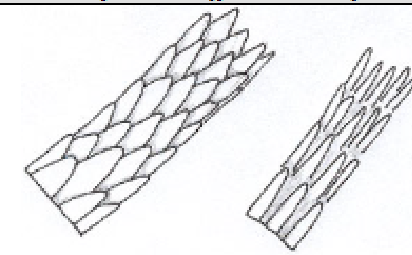
Coronal



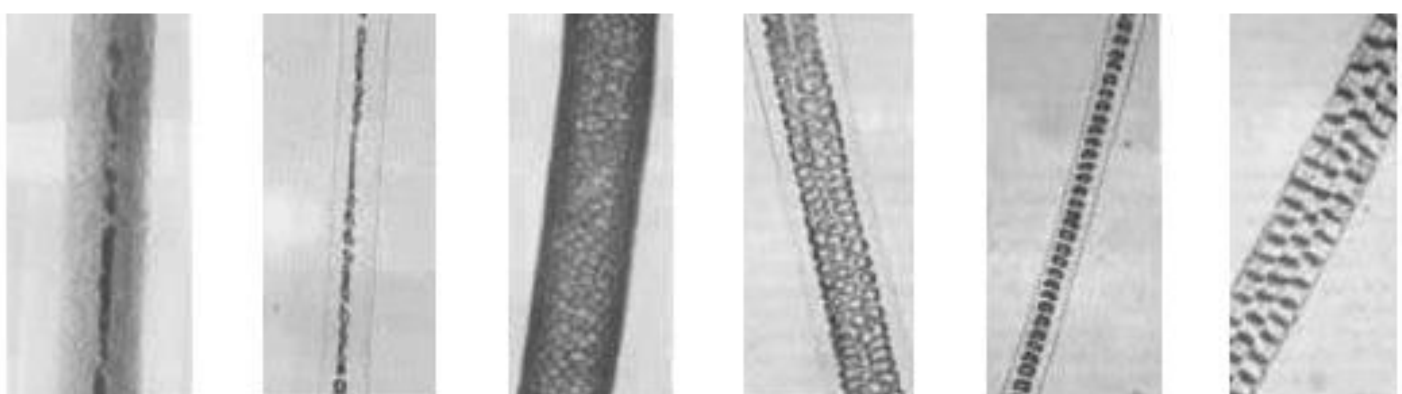
Imbricate

- D. cuticle scales:
  - 1. Animals: resemble petals (spinous-cat) or a stack of crowns (coronal-mouse)
  - 2. Humans: flattened and narrow (imbricate)

Cuticle scales differ between species of animals;
three basic scale structures include:

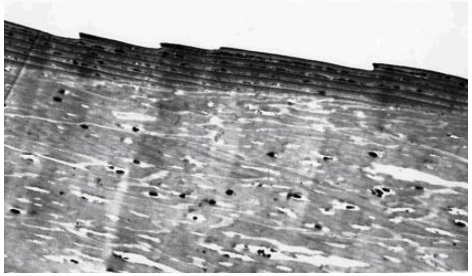
coronal (crown-like)	Imbricate (flattened)	Spinous (petal-like)
		
• Found in hairs of very fine diameter and resemble a stack of paper cups • Coronal scales are commonly found in the hairs of small rodents and bats but rarely in human hairs	• Overlapping scales with narrow margins • They are commonly found in human hairs and many animal hairs	• Triangular in shape and protrude from the hair shaft • Found on the fur hairs of mink, seals, cats, and some other animals. • They are never found in human hairs

Animal hairs also show a wide variety of medulla patterns:



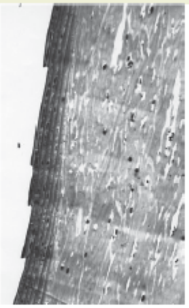
Human Dog Deer Rabbit Cat Mouse

XII. Using Hair in an Investigation



- A. Macroscopic investigations indicate
  - Length, color, curliness
- B. Phase contrast microscopy shows
  - presence of dye or other treatments
- C. Electron microscopes yield yet more detail
- 50000x
- D. Chemical tests
  - presence of various substances
- E. Examining a hair shaft
  - timeline for exposure to toxins
- F. Neutron Activation Analysis (NAA)
  - concentrations of substances

Figure 3-14 *A transmission electron microscope produced this extremely detailed image of a long section of human hair. Notice the overlapping cuticle scales on the left side and the pigment granules in the cortex.*



Courtesy, FBI; photos by Sandra Koch & Douglas W. Deedrick

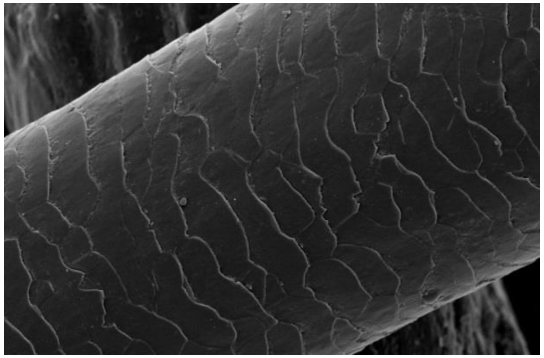
Hair viewed for forensic investigations is studied both **macroscopically** and **microscopically**

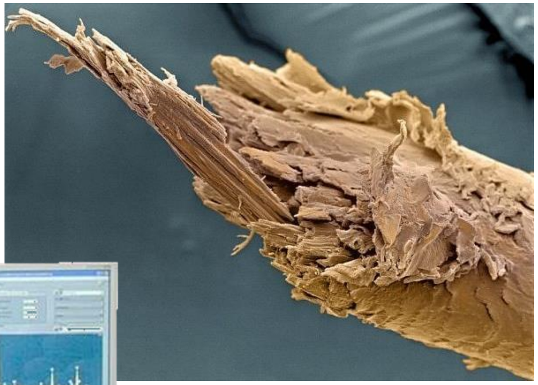
Different kinds of microscopes provide different kinds of evidence.

Comparison microscopes are especially important tools to the forensic investigation of hair.

A **fluorescence** microscope is equipped with filters to detect fluoresced light, indicating the presence of a dye or other treatment.

<u>Electron</u> microscopes provide incredible detail of the surface or interior of the sample, magnifying the object 50,000 times or more.

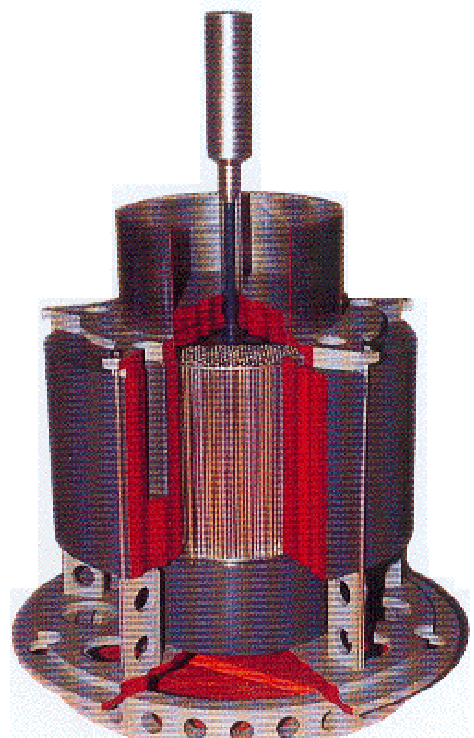




Neutron Activation Analysis (NAA)

A useful technique that can identify up to 14 different **elements** in a single two-centimeter-long strand of human hair.

The probability of the hairs of two individuals having the same concentration of these different elements is about one in a million.



XIII. Testing the Hair

- A. Microscopic assessment
  - Cost effective and quick
- B. Blood test
  - Determine blood type
- C. DNA analysis – PCR analysis
  - Identification with a high degree of confidence
- D. mtDNA genetic relationship through the mother.

Testing the Hair Follicle

If hair is forcibly removed from a victim or suspect, the entire hair follicle (called a **follicular tag**) may be present. If so, **blood** and **tissue** attached to the follicle may be analyzed for blood type and **DNA**.

Naturally shed hairs, such as a head hair dislodged through combing, display undamaged, club-shaped roots.

A hair forcibly removed from the scalp will exhibit stretching and damage to the root area.

Forcibly removed hairs may have tissue attached.

XIV. Drug test

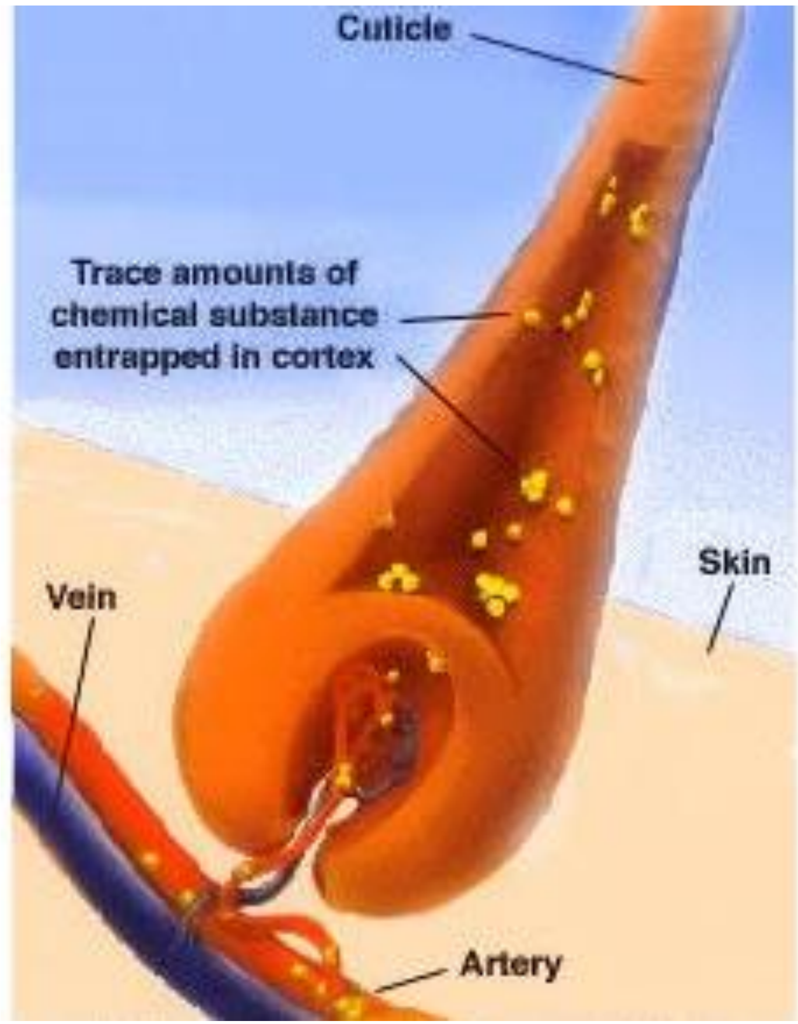
- A. 90-120 strands at least 1 ½ inches long
- B. Up to 90 days since hair grows ½ inch/month (1.3 cm)
  - 1. Amphetamine/methamphetamine/ecstasy
  - 2. Marijuana
  - 3. Cocaine
  - 4. Opiates (codeine, morphine)
  - 5. Phencyclidine (PCP)

Testing for Substances in the Hair Shaft

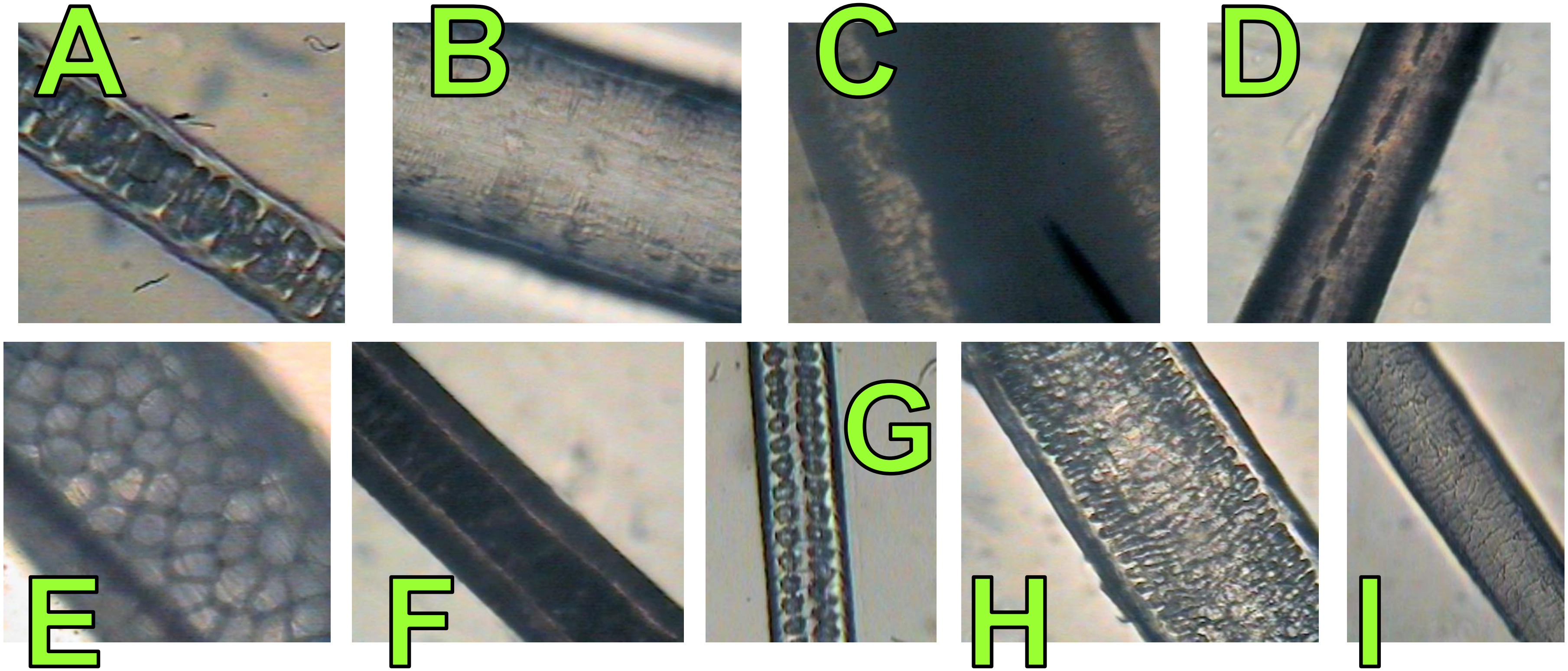
Because hair grows out of the **skin**, chemicals that the skin **absorbs** and some toxins and drugs which an individual **ingests** can leave **traces** in the hair.

In order to test hair, it must first be **dissolved** in an organic solvent that breaks down the **keratin** and releases any substances that have been incorporated into the hair.

A forensic chemist can then perform chemical tests for the presence of various substances to provide evidence of **poisoning** or drug use.



Can you identify the animal hairs shown?



Think About It …

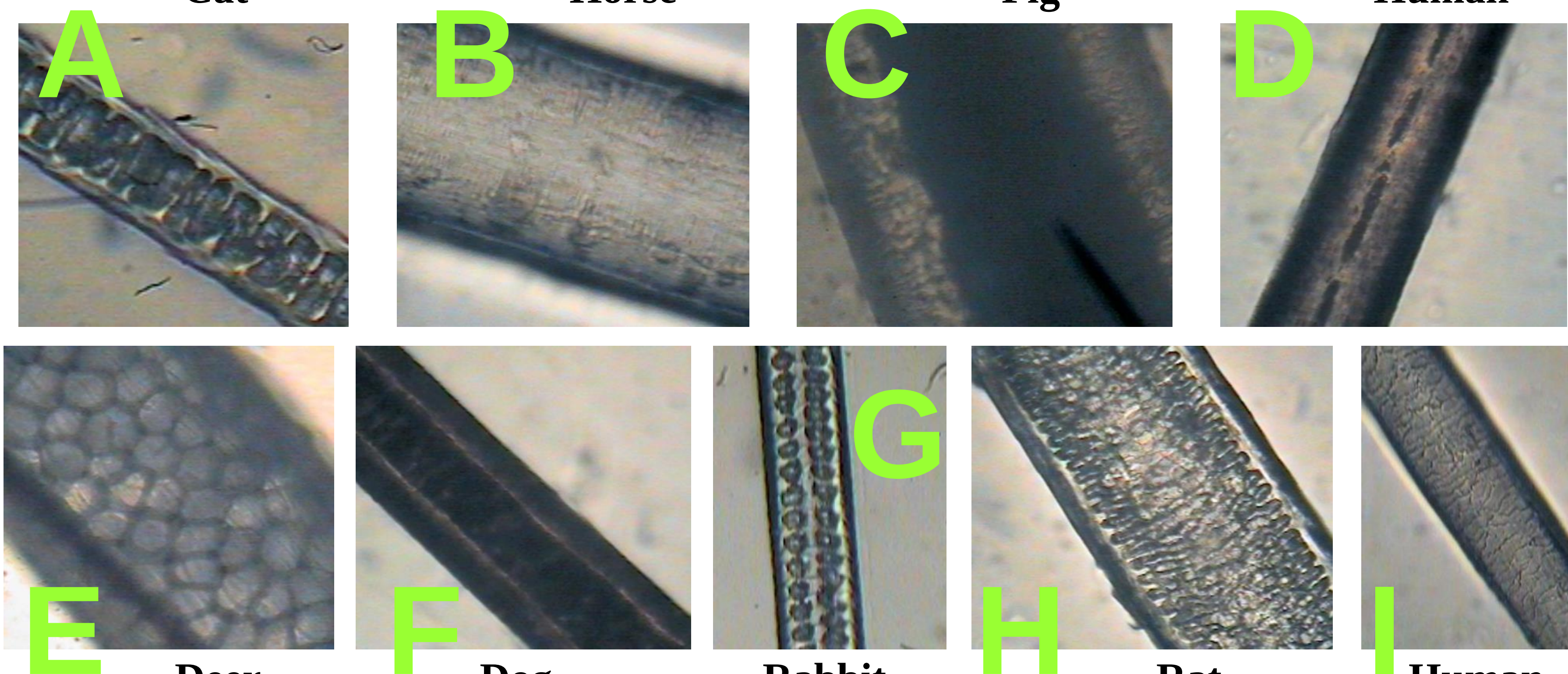
(1) In which samples are we viewing the cuticle? How do they compare?

(2) In which samples are we viewing the medulla? How do they compare?

(3) What characteristics can be used to identify hair samples?

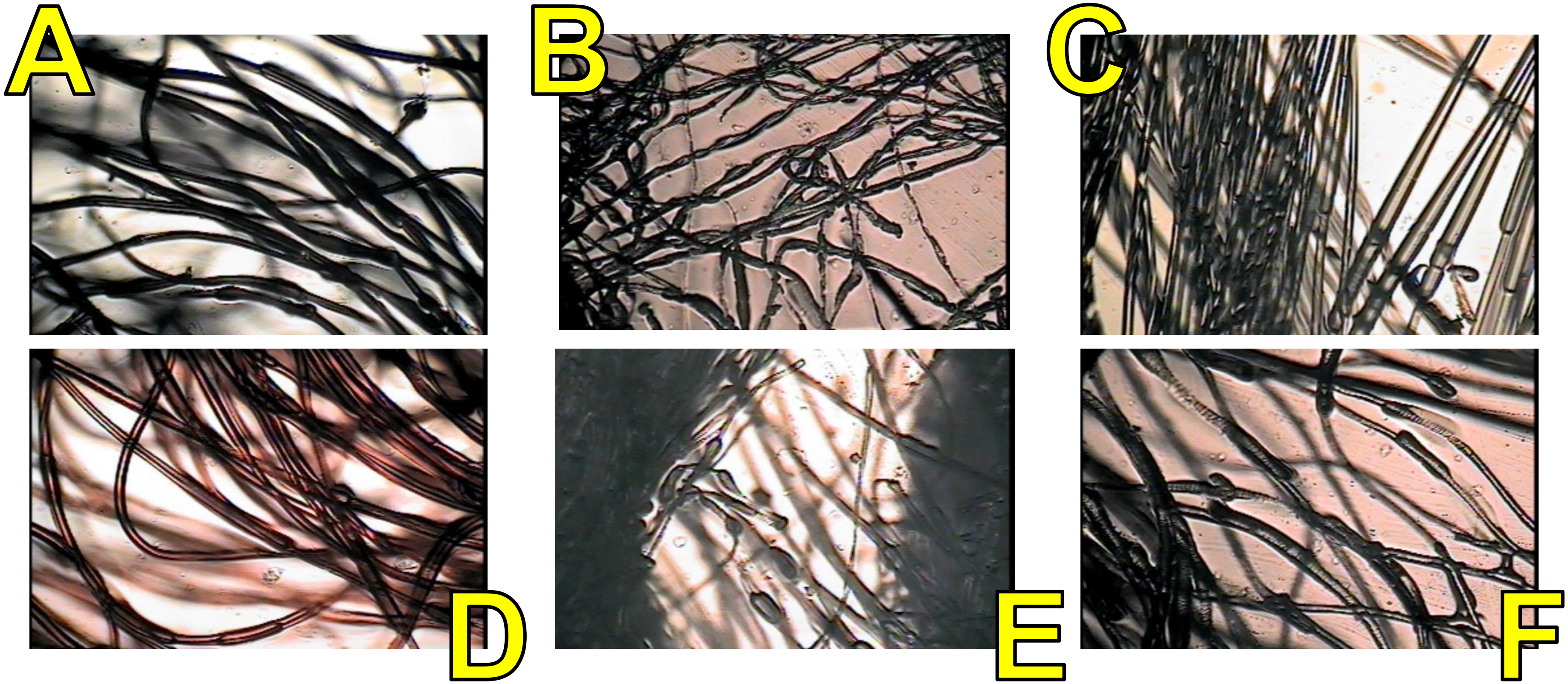
Types of Animal Hairs - Key

Cat Horse Pig Human



Deer Dog Rabbit Rat Human

Can you identify the types of fibers shown?



Think About It …

(1) Which samples are natural fibers?

(2) Which samples are synthetic fibers?

(3) What characteristics can be used to identify fiber samples?

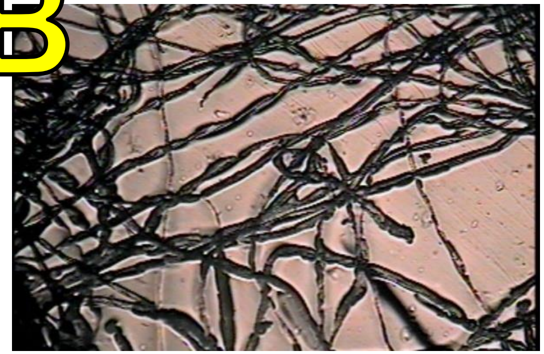
Types of Fibers - Key

A

Acrylic Yarn

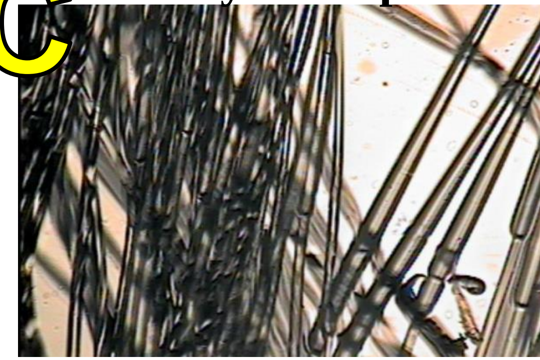
B

Cotton Yarn



C

Nylon Rope

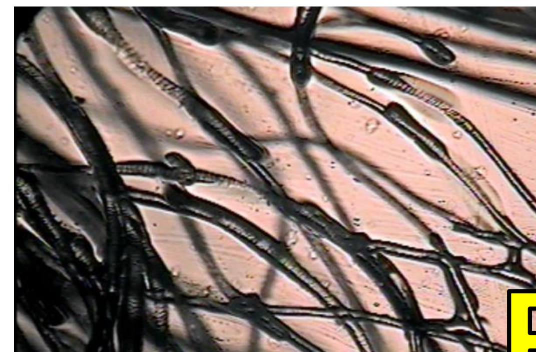


D

Polyester Yarn

E

Rayon Rope



F

Wool Yarn

Fiber Evidence

A **fiber** is the smallest unit of a textile material that has a **length** many times greater than its **diameter**. A fiber can be spun with other fibers to form a **yarn** that can be woven or knitted to form a fabric.

The **type** and length of fiber used, the type of **spinning** method, and the type of **fabric** construction all affect the transfer of fibers and the significance of fiber associations. This becomes very important when there is a possibility of fiber **transfer** between a suspect and a victim during the commission of a crime.

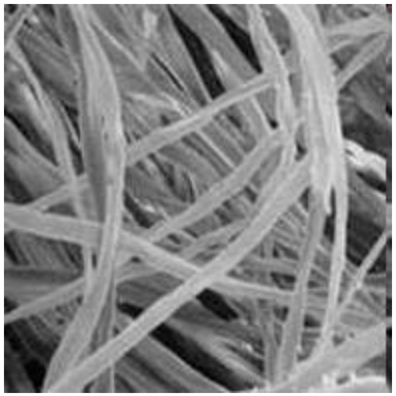
Matching **unique** fibers on the clothing of a victim to fibers on a suspect's clothing can be very helpful to an investigation, whereas the matching of **common** fibers such as white cotton or blue denim fibers would be less helpful.

The discovery of **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

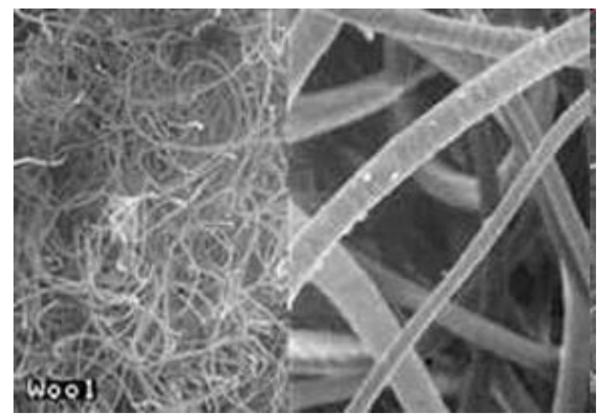
Natural Fibers

Many different **natural** fibers that come from plants and animals are used in the production of fabric.



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

The animal fiber most frequently used in the production of textile materials is **wool**, and the most common wool fibers originate from sheep.

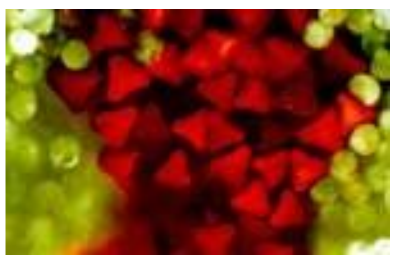


http://www.fireflydiapers.com/articles/diaperarticle_naturalfibersabsorb.htm

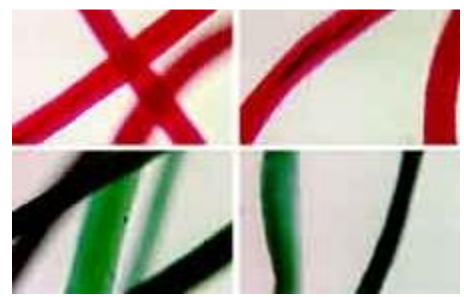
Synthetic Fibers

More than half of all fibers used in the production of textile materials are synthetic or **man-made**.

Nylon, rayon, and polyester are all examples of **synthetic** fibers.



Cross-section of a man-made fiber



Fibers under a microscope

Images: http://www.trashforteaching.org/phpstore/product_images/YarnWS.JPG
http://www.fbi.gov/hq/lab/fsc/backissu/july2000/deedric3.htm#Fiber%20Evidence
http://www.jivepuppi.com/images/fiber_evidence.jpg

Hair & Fiber Identification Lab

Directions:

Your team will need to use a microscope to document all the hairs and fibers in your set.

Write the name of the hair or fiber on the line and then draw what you see under <u>medium</u> or <u>high</u> power. Be sure to indicate the power of magnification!

Add a description that highlights the <u>unique characteristics</u> of each hair and fiber sample.

Pay attention to <u>details</u> to help you identify samples during the Hair & Fiber Challenge activity.


Hair and Fiber Samples Name ____________

Part 1: Use a microscope to examine the **HAIR** samples provided by your teacher. Sketch the view under **MEDIUM POWER** and write a **DESCRIPTION** that would help you identify the sample, such as unique marks or other details.

________ Power = ___X Description:	________ Power = ___X Description:	________ Power = ___X Description:
________ Power = ___X Description:	________ Power = ___X Description:	________ Power = ___X Description:
________ Power = ___X Description:	________ Power = ___X Desc	________ Power = ___X

T. Trim

Part 2: Use a microscope to examine the **FIBER** samples provided by your teacher. Sketch the view under **MEDIUM POWER** and write a **DESCRIPTION** that would help you identify the sample, such as unique marks or other details.

________ Power = ___X Description:	________ Power = ___X Description:	________ Power = ___X Description:
________ Power = ___X Description:	________ Power = ___X Description:	________ Power = ___X Description:

Part 3: Try to identify the **HAIRS & FIBERS** on the practice slides. Write your guesses in the space below.

#1 ____________	#7 ____________
#2 ____________	#8 ____________
#3 ____________	#9 ____________
#4 ____________	#10 ____________
#5 ____________	#11 ________ & ________
#6 ____________	#12 ________ & ________

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