Trace Evidence I

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On Line Assignment 5

Assignment 5 will ONLY be available online
February 10 at 8 am to February 14 at 11:59 pm

Next Week Midterm*

MIDTERM Saturday February 8. 10:00am to 10:50 am on line

- Multiple choice, emphasis on text with clarification material from lectures
- Will cover up to and including both trace evidence lectures (today and Thursday)

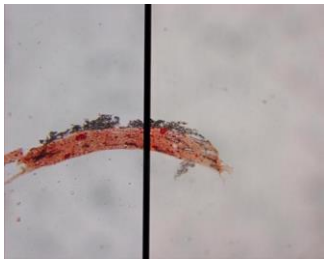
Overview

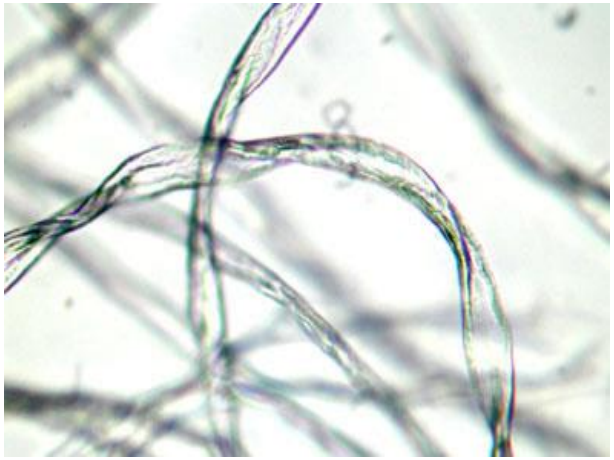
Trace Evidence Introduction

Hair

Fiber

Trace Evidence





Trace Evidence in the Laboratory

Most common physical evidence that undergoes standard laboratory analysis using morphological observation

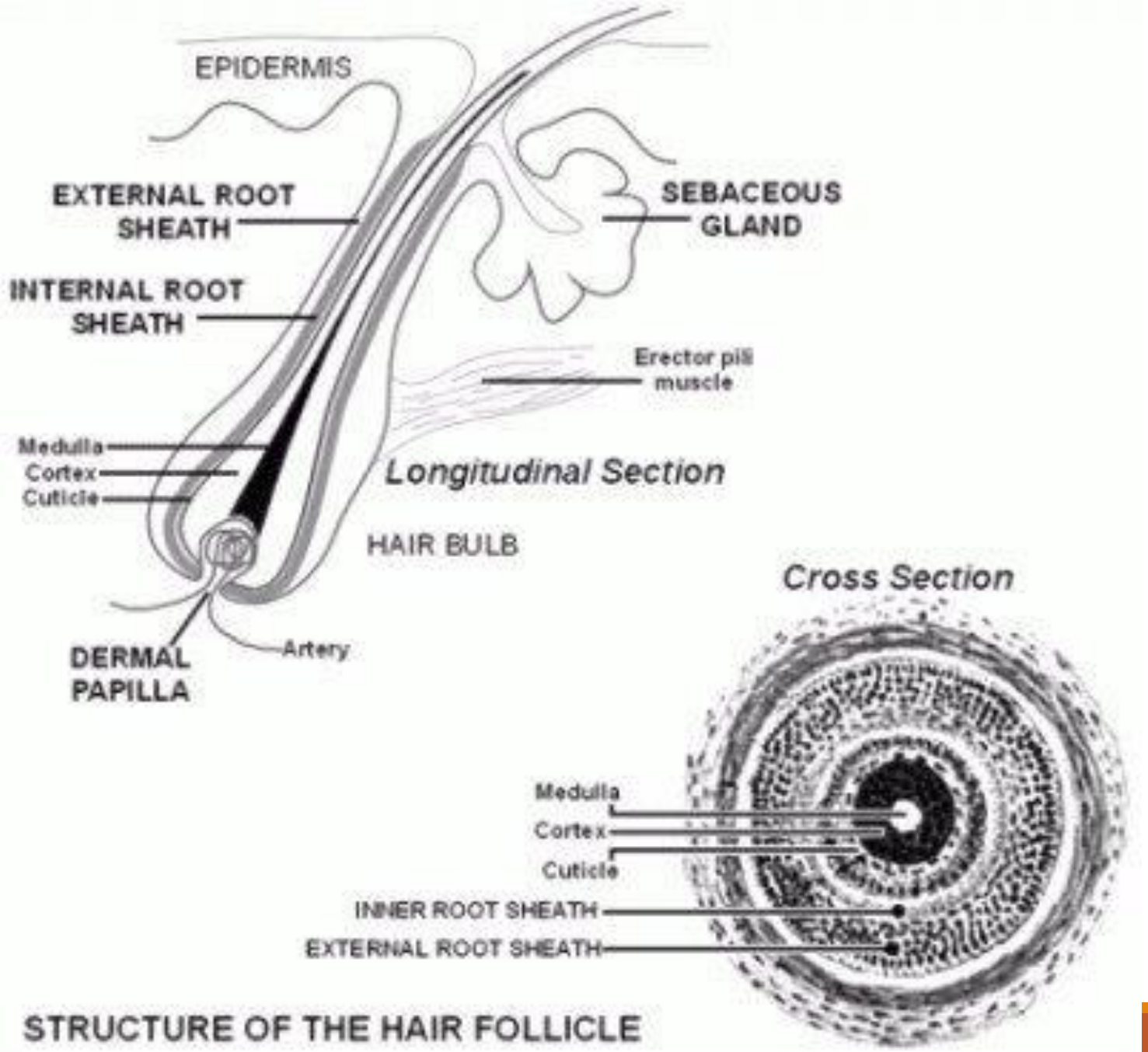
- Hairs
- Fibers
- Paints
- Soil
- Glass

Hair

- Hair is encountered as physical evidence in a wide variety of crimes.
- Although it is not yet possible to individualize a human hair to any single head or body through its morphology, it still has value as physical evidence.
- When properly collected and submitted to the laboratory accompanied by an adequate number of standard / reference samples, hair can provide strong corroborative evidence for placing an individual at a crime scene.

Morphology of Hair

- Hair is an appendage of the skin that grows out of an organ known as the hair follicle.
- The length of a hair extends from its root or bulb embedded in the follicle, continues into a shaft, and terminates at a tip end.
- The shaft, which is composed of three layers -the cuticle, cortex, and medulla - is subjected to the most intense examination by the forensic scientist.



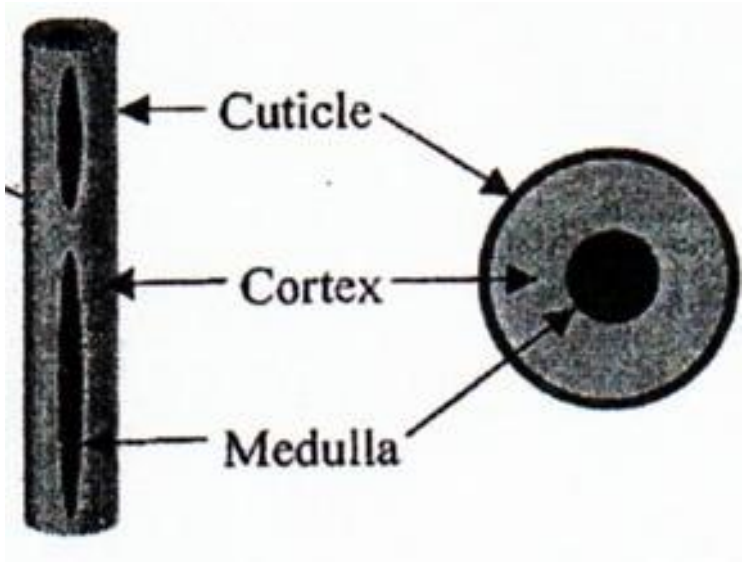
STRUCTURE OF THE HAIR FOLLICLE

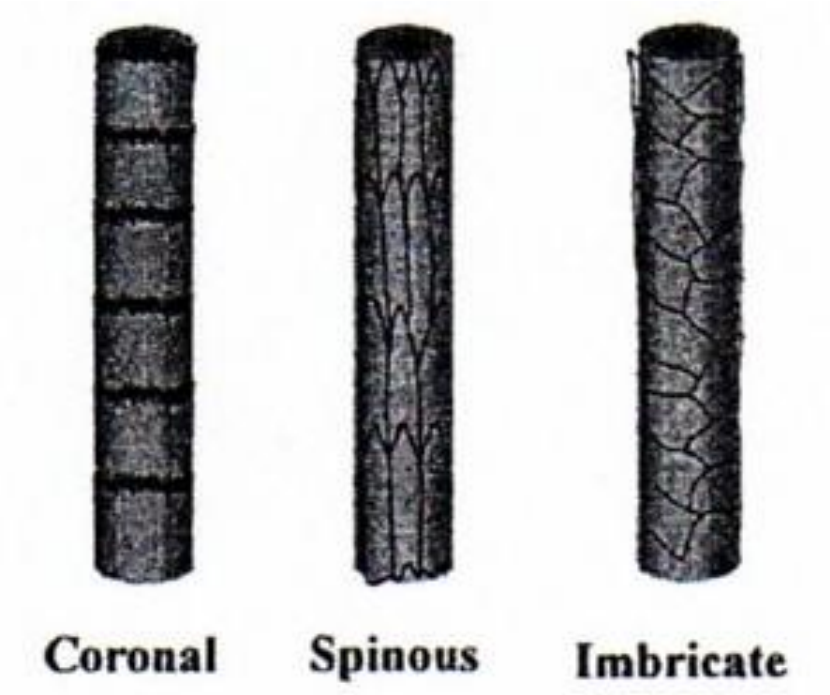
Morphology of Hair

Cuticle

- A scale structure that covers the exterior of the hair
- Scales appear flattened and point toward the tip of the hair shaft
- Not useful for individualization of humans, but is quite useful in discriminating between species, i.e. Cat vs Dog vs Human

Hair Cuticle





Animal Hair Gallery

http://www.microlabgallery.com/hair.aspx

Animal Hairs

Human Human Cat Deer Dog

http://www.microlabgallery.com/hair.aspx

Cortex*

The cortex is the main body of the hair shaft.

- Its major forensic importance is the fact that it is embedded with the pigment granules that impart hair with color.
- The color, shape, and distribution of these granules provide the forensic scientist with important points of comparison among the hairs of different individuals.
- Colour is dependent on the amount and type of melanin in the cortex

- Lack of melanin will be the case of gray or white hair

Figure 97. Photomicrograph of Pigment Distribution in Human Hair

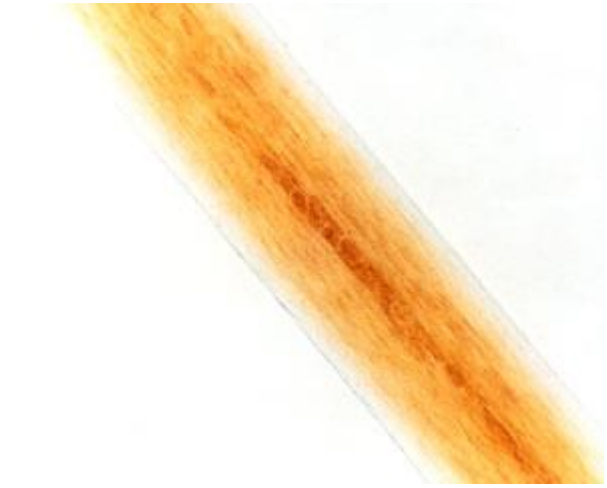


Figure 98. Photomicrograph of Pigment Distribution in Red Human Hair

Figure 99. Photomicrograph of Pigment Distribution in Animal Hair

http://www.fbi.gov/about-us/lab/forensic-science-communications/fsc/july2004/research/2004_03_research02.htm

Medulla

Central canal running through the hair shaft

Medullary index

- The ratio of the medulla diameter to the diameter of the hair shaft
- In animals, the medulla occupies over half of the hair's diameter
- In humans generally less than 1/3

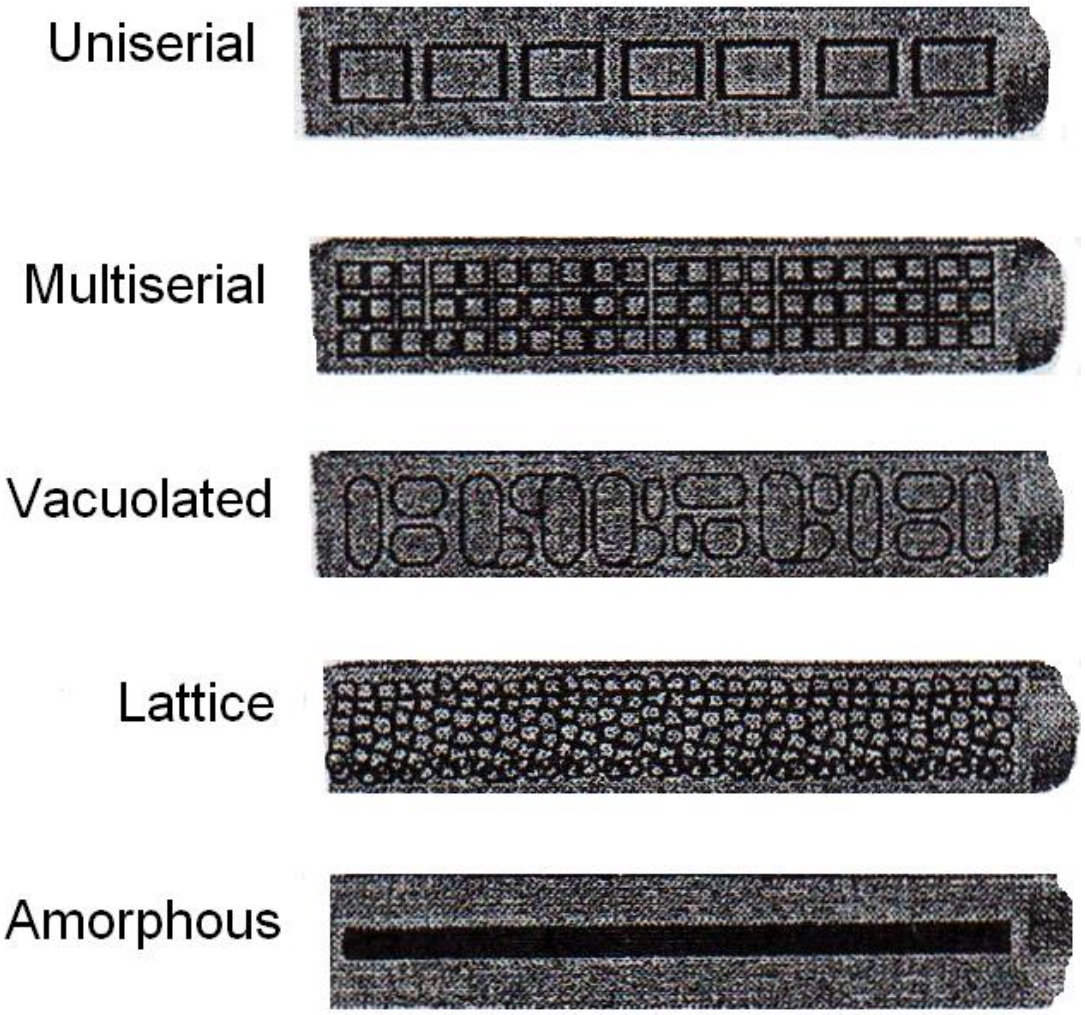
Varies within and between individuals

- Human hair often lacks a medulla, or if present is fragmented

Medulla Structure/Shape

Absent Fragmented Intermittent Continuous

Medulla Patterns, diagram



Root

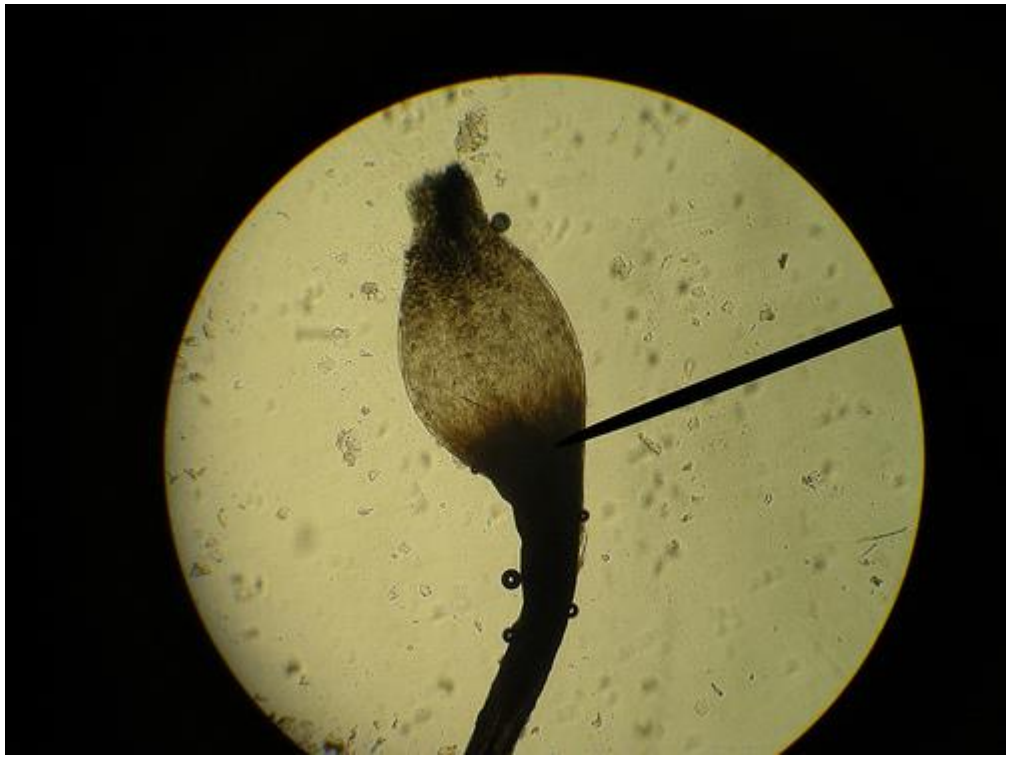
- The root and other surrounding cells in the hair follicle provide the tools necessary to produce hair and continue its growth.
- When pulled from the head, some translucent tissue surrounding the hair's shaft near the root may be found. This is called a follicular tag.
- By using DNA analysis on the follicular tag, the hair may be individualized.

Hair Growth

3 stages of hair growth distinguished by root characteristics

- Anagen Phase
  - The initial phase of growth in which the hair follicle is actively producing hair
  - Appearance: The root bulb would appear flame shaped
- Catagen Phase
  - Transition phase of growth between anagen and telogen
  - Appearance: Root appears elongated
- Telogen Phase
  - Final growth phase in which the hair falls out of the skin
  - Appearance: Root takes on club-shaped appearance

Anagen Phase



Flame Shaped

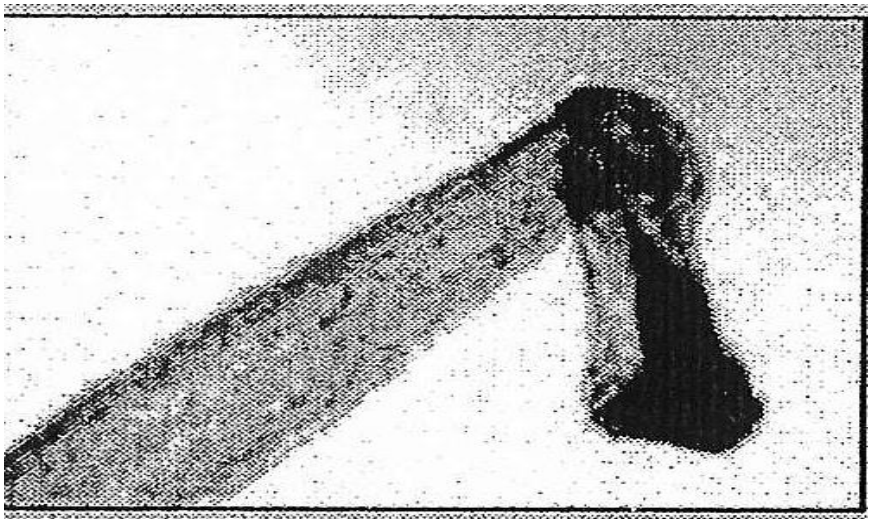
Catagen Phase

Telogen Phase

Forcibly Removed Hair

May or may not contain the follicular tag

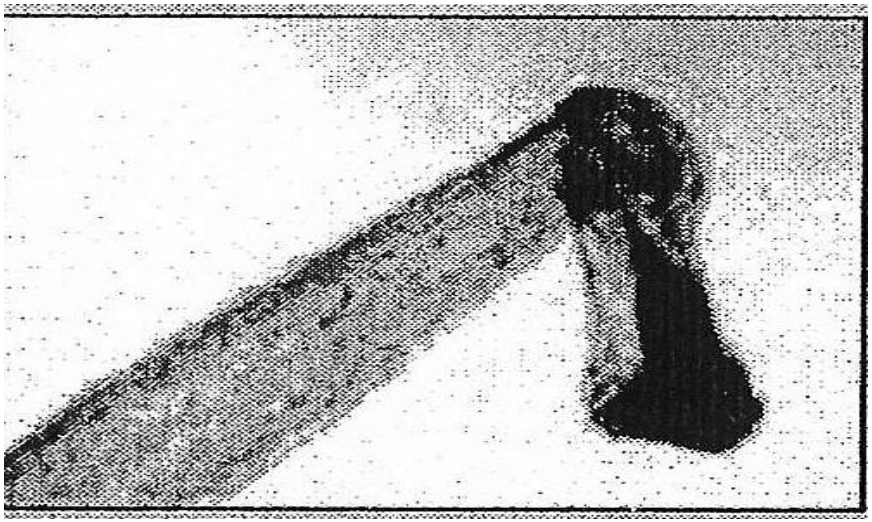
- Follicular tag may contain sufficient DNA for a DNA profile – What type of DNA?



Forcibly Removed Hair

May or may not contain the follicular tag

- Follicular tag may contain sufficient DNA for a DNA profile – genomic DNA



Hair Comparisons*

- Determine whether the hair is of human or animal origin

- Does the hair in question share the same characteristics as the suspect/victim/witness' reference hair samples

Hair Comparisons

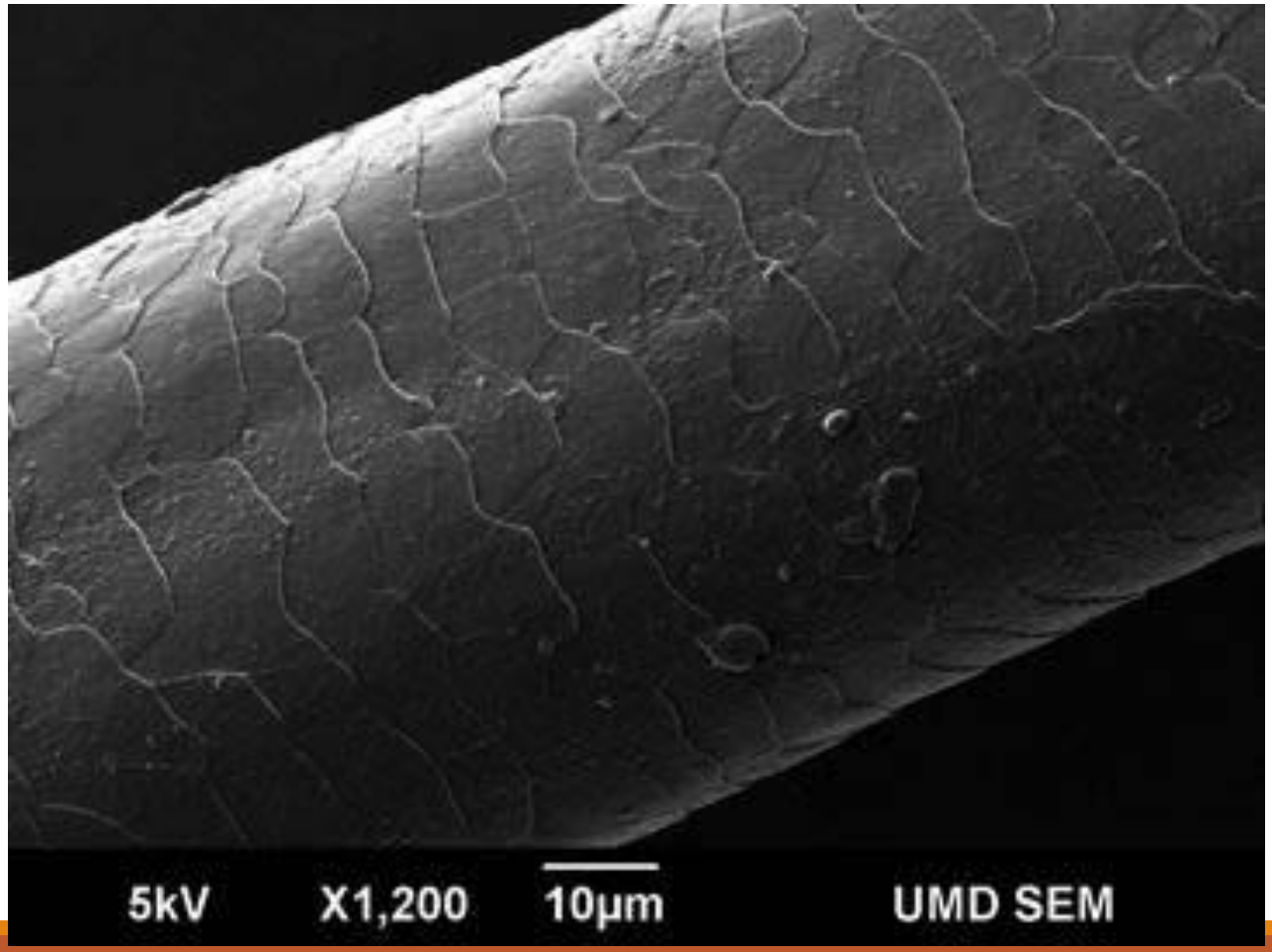
Examine

- Length and diameter
- Scale structure (cuticle)
- The distribution, shape, and color intensity of the pigment granules present in the cortex.
- The presence or absence of a medulla.
- Medullary Index, Medullary Shape, Medullary Pattern

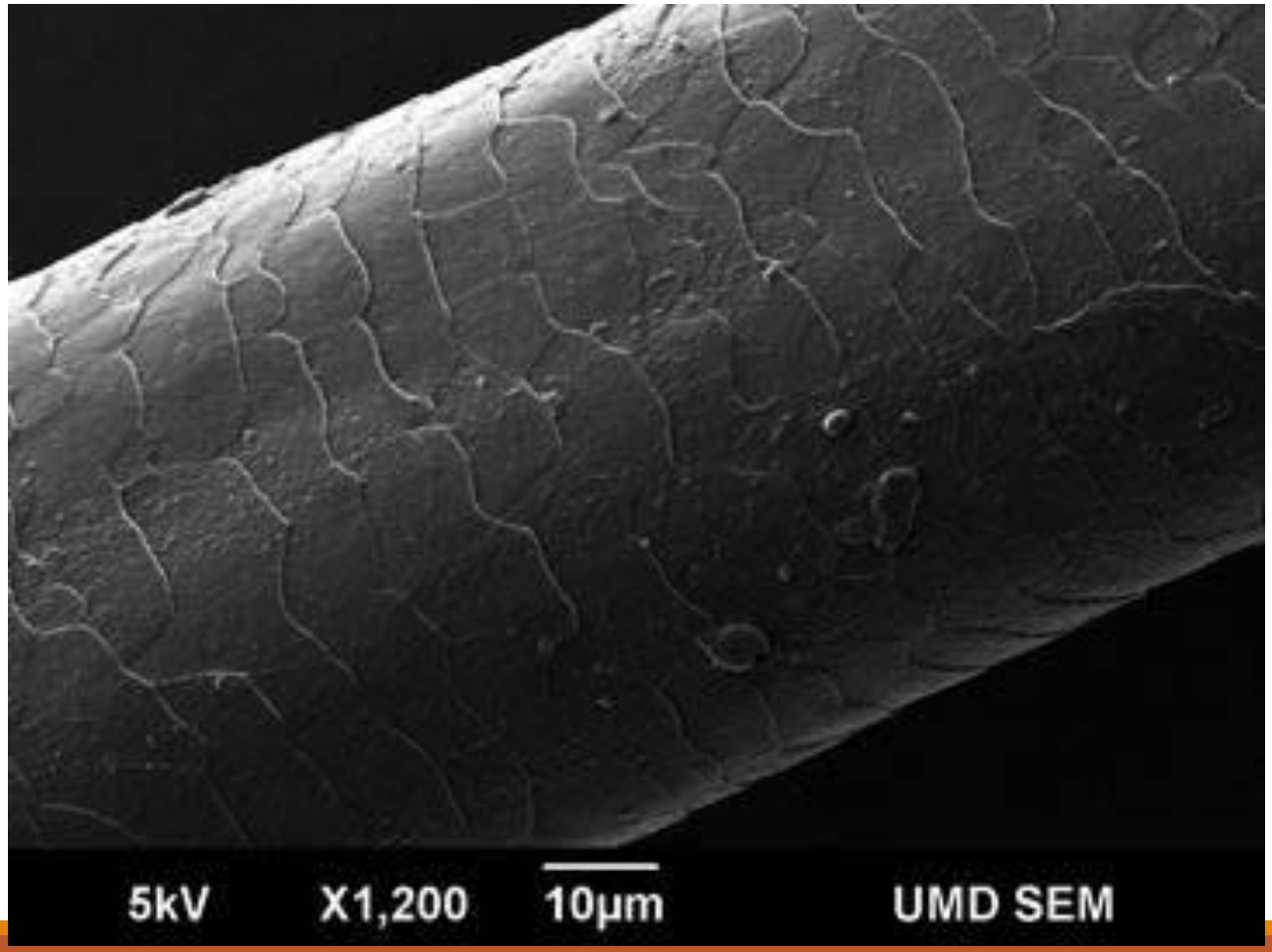
Microscopic hair examinations tend to be subjective and highly dependent on the skills and integrity of the analyst

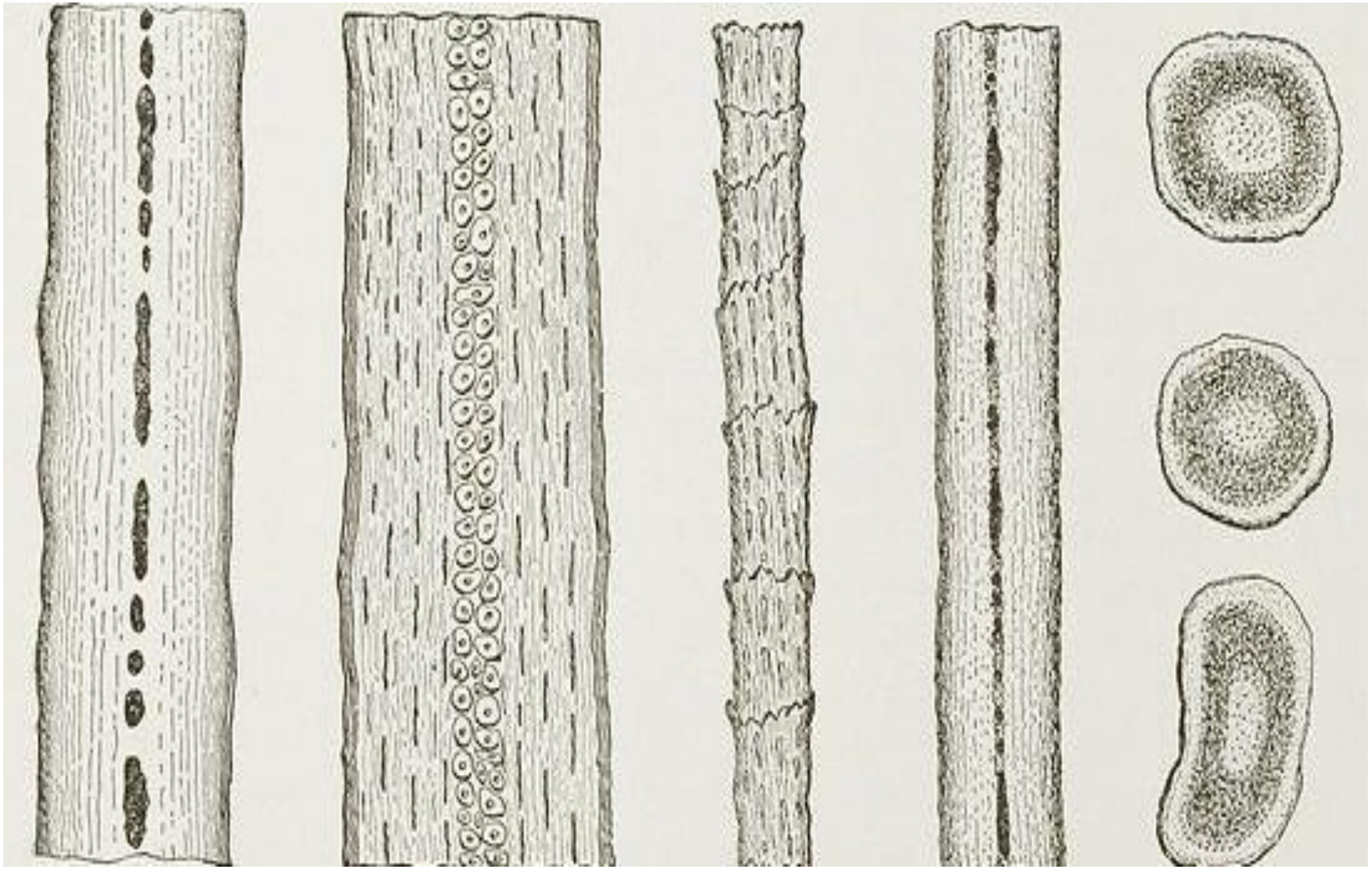
Human Hair

Human Hair – what layer is captured in the image?



Human Hair – Cuticle, Imbricate





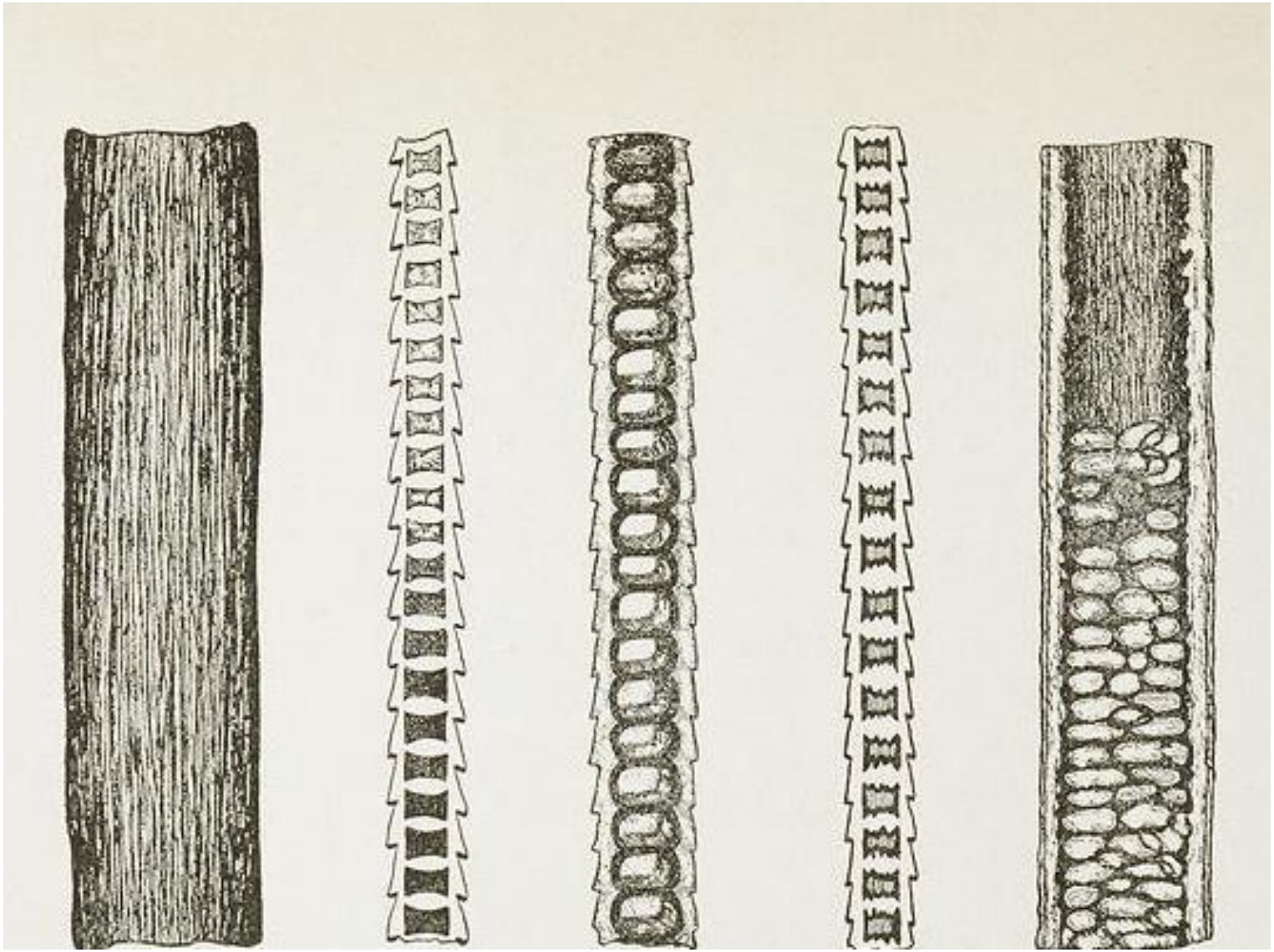
Human

Human Treated with Caustic soda (NaOH)

Hair from the back of hand (Coronal)

Human Head

(J.F. Babcock-Del.)

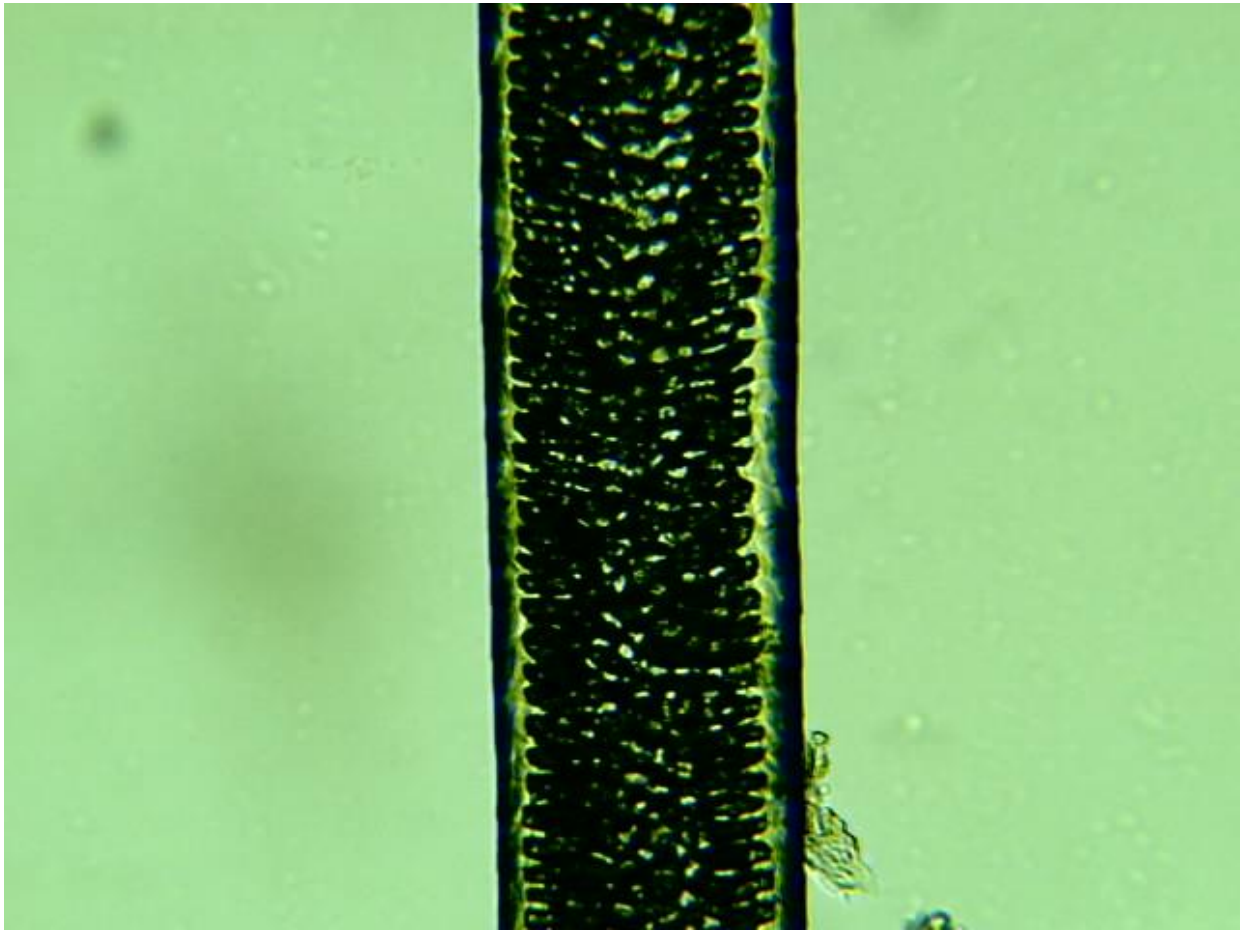


Horse Mouse Cat Chinchilla Seal

(J.F. Babcock-Del.)

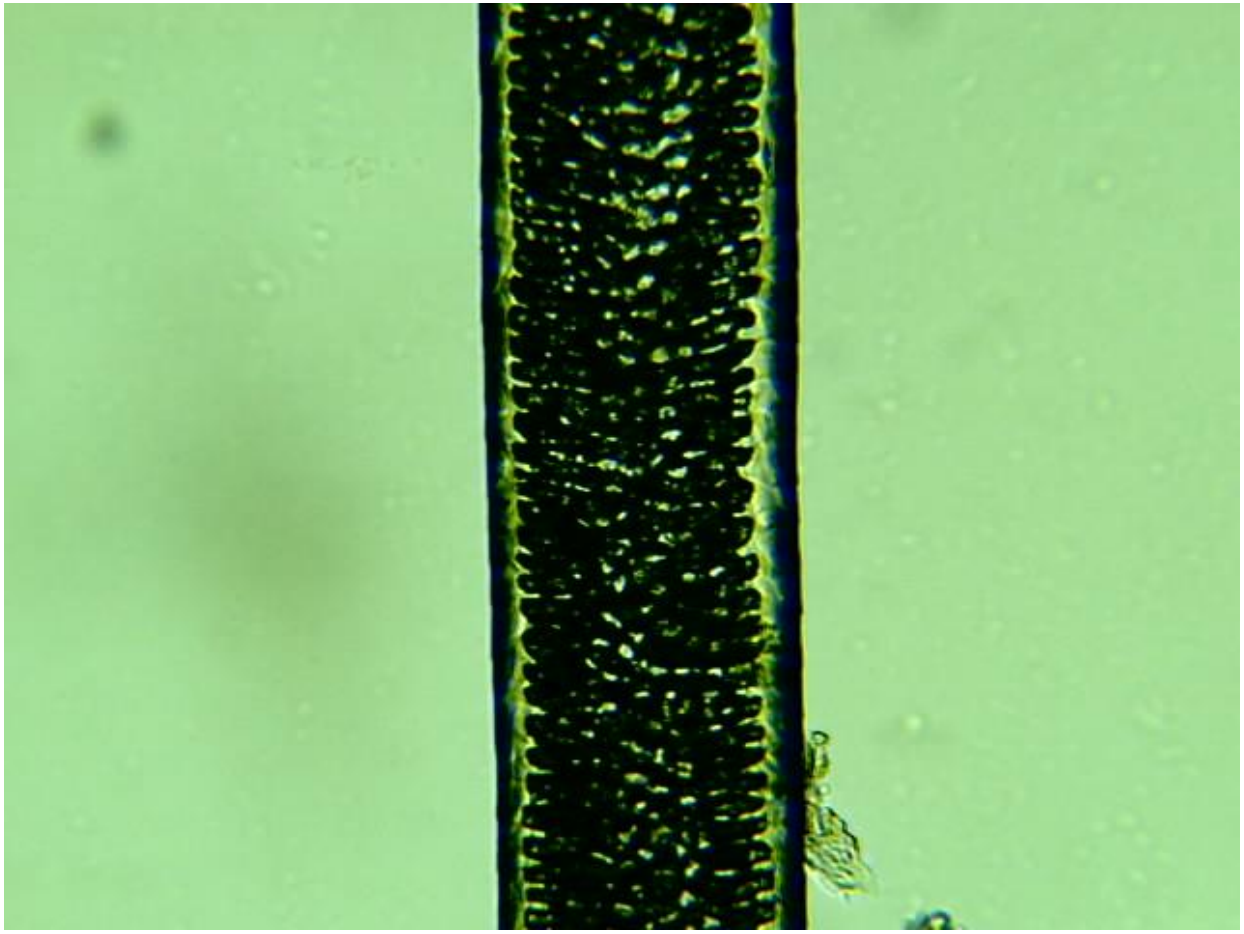
– Medulla Lattice

Notice the medullary index. Relevance?



Rat Hair – Medulla Lattice

Notice the medullary index. Relevance?



Factors to Consider

Comparing human hair to that of animals is relatively simple, however, comparing human hairs is quite difficult

- Hair morphology varies both within and between individuals
- Focus on matching colour, length and diameter

Is the Hair bleached or dyed?

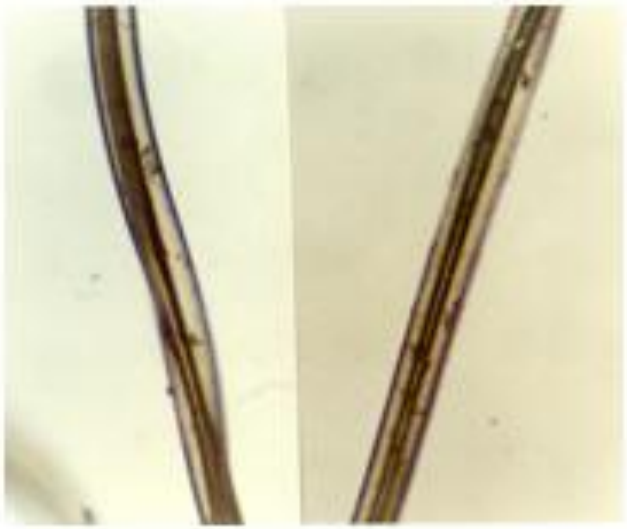
- Dyed colour is present in the cuticle as well as the cortex
- Bleached hair removes all melanin from the cortex leaving it a yellowish colour

Presence of disease, fungal or nit infections

Morphological Observation

Comparison Microscope

- View unknown and reference samples side-by-side



Questions see chapter 13 of text

Can the body area from which a hair originated be determined?

Can the racial origin of hair be determined?

Can the age and sex of an individual be determined from a hair sample?

Is it possible to determine if a hair was forcibly removed from the body?

Is it possible to determine whether hair came from a deceased individual?

Can DNA individualize a human hair?

Hair and DNA

- DNA profiling may allow individualization of human hair.
- The probability of detecting DNA in hair roots is more likely for hair being examined in its anagen or early growth phase as opposed to its catagen (middle) or telogen (final) phases.
- Often, when hair is forcibly removed a follicular tag, a translucent piece of tissue surrounding the hair's shaft near the root may be present.
- This has proven to be a rich source of nuclear DNA associated with hair.

Hair and Mitochondrial DNA

- Mitochondrial DNA can be extracted from the hair shaft.
- Mitochondrial DNA is found in cellular material located outside of the nucleus and it is transmitted primarily from the mother to child.
- As a rule, all positive microscopic hair comparisons must be confirmed by DNA analysis.

Collection and Preservation

- As a general rule, forensic hair comparisons involve either head hair or pubic hair.
- The collection of 50 full-length hairs from all areas of the scalp will normally ensure a representative sampling of head hair.
- A minimum collection of two dozen full-length pubic hairs should cover the range of characteristics present in pubic hair.
- Hair samples are also collected from the victim of suspicious deaths during an autopsy.

Microscopic Hair Comparisons*

- Must be regarded by police and the courts (including lay persons, i.e. Juries) as presumptive

- Positive comparisons must be verified with DNA analysis

Limitations

M. M. Houk and B. Budowle, 'Correlation of Microscopic and Mitochondrial DNA Hair Comparisons,' *Journal of Forensic Sciences*; 47 (2002): 964

- Determined the Mitochondrial DNA profile for hair samples that FBI hair examiners had positively identified as a match via morphological observation (microscopically)

- 11% of the 'positive matches' did not share the same Mitochondrial DNA profile

Examination of Fibers

Polymers, are macromolecules composed of a large number of atoms arranged in repeating units known as monomers.

Natural

- Of plant and animal origin

Manufactured or Synthetic

- Synthesized (usually chemically)

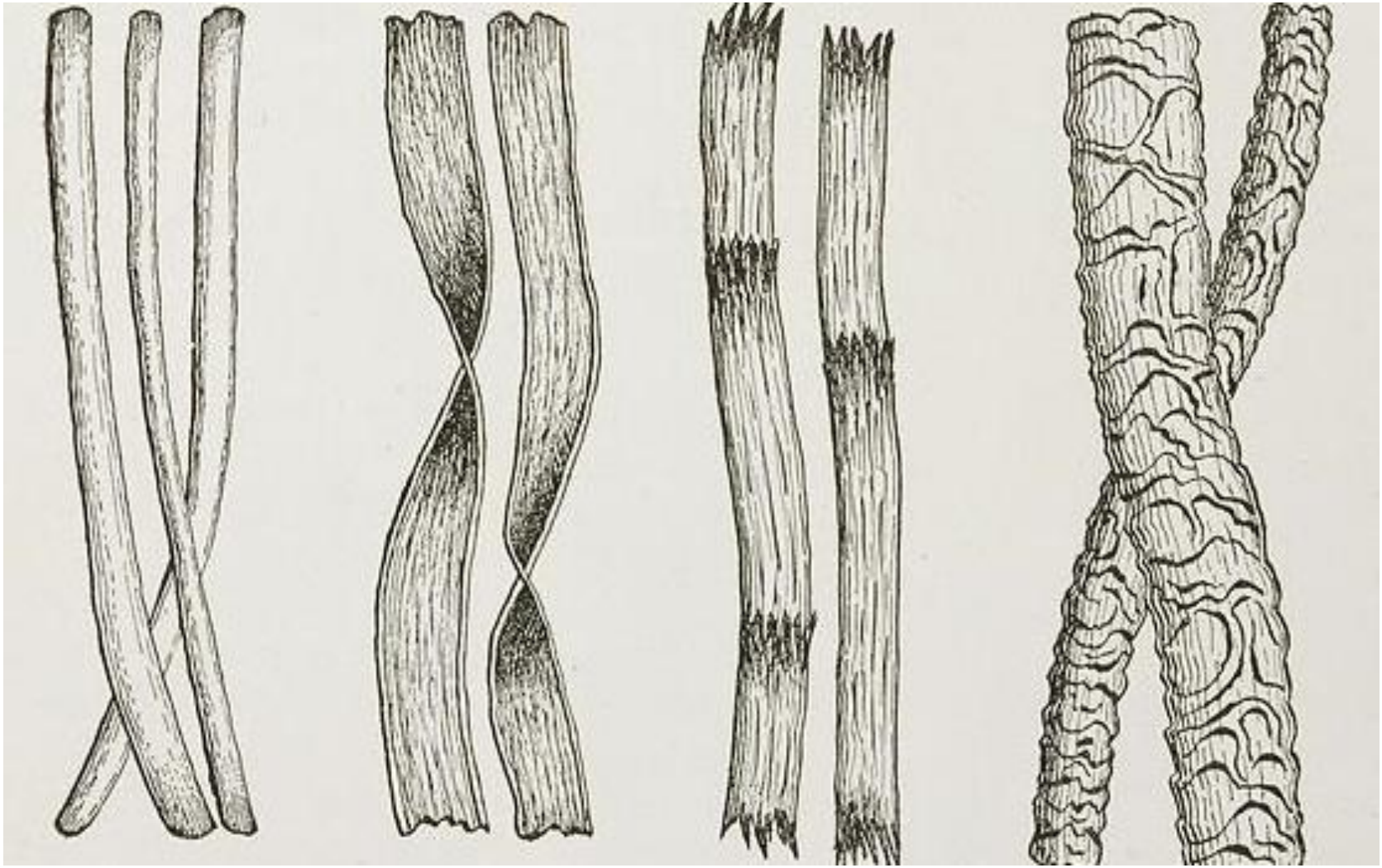
Natural Fibers

Of animal origin

- Wool (sheep)
- Mohair, cashmere (goat)
- Furs (mink, rabbit, beaver, muskrat, chinchilla)

Of plant origin

- Cotton
- Hemp
- Flax



Silk Cotton Flax Wool

(J.F. Babcock-Del.)

Polymers

Chemically manufactured

- Include (but are not limited to)
  - Plastics
  - Paints
  - Adhesives
  - Rubber

In Nature

- Animal hair structure is a polymer composed of thousands of amino acids
- Cellulose (ingredient of wood and cotton) is a polymer (polysaccharide) composed of thousands of carbohydrates (sugars)

Synthetic Fibers*

Man-made fibers are manufactured.

- Regenerated fibers are manufactured from natural raw materials and include rayon, acetate, and triacetate.
- Synthetic fibers are produced solely from synthetic chemicals and include nylons, polyesters, and acrylics.

See Table chapter 13 Major Generic Fibers in your text for a list of major generic fibers, their characteristics and uses – e.g. aramid, PBI

Fiber Evidence

- The quality of the fiber evidence depends on the ability of the criminalist to identify the origin of the fiber or at least be able to narrow the possibilities to a limited number of sources.
- If the examiner is presented with fabrics that can be exactly fitted together at their torn edges, it is a virtual certainty that the fabrics were of common origin.

Fiber Comparisons

Like hairs, the use of a comparison microscope is essential

- Examine: Colour, diameter, lengthwise striations, the presence of delustering particles and other additives in the manufacturing process

Chemical composition

- If the morphological characteristics match, chemical analyses are required to conclude the possibility of two fibres having the same origin

Microspectrophotometer

Uses microscopy and spectrophotometry to profile fibers and other trace evidence

- Visible light source
- Infrared light source
- Ultra-violet light source
- Each gives a spectrum of the sample and reference for comparison

Obtain spectral profile(s)

- Can differentiate similar colours
- Synthetic polymers absorb infrared light in a characteristic pattern that can be specific to that type of textile

Collection and Preservation

- The investigator's task of looking for minute strands of fibers often becomes one of identifying and preserving potential "carriers" of fiber evidence.
- Relevant articles of clothing should be packaged carefully in separate paper bags.
- If it is necessary to remove a fiber from an object, the investigator must use clean forceps, place it in a small sheet of paper, fold and label the paper, and place the paper packet inside another container.

Review

Hair

- Root, shaft and tip
- Cuticle, cortex and medulla
- Anagen, catagen, telogen phases
- Follicular tag
- Comparing hairs, factors to consider
- Nuclear DNA, mitochondrial DNA
- Collection

Fibers

- Natural and synthetic
- Polymers
- Comparison microscopy
- Microspectroscopy