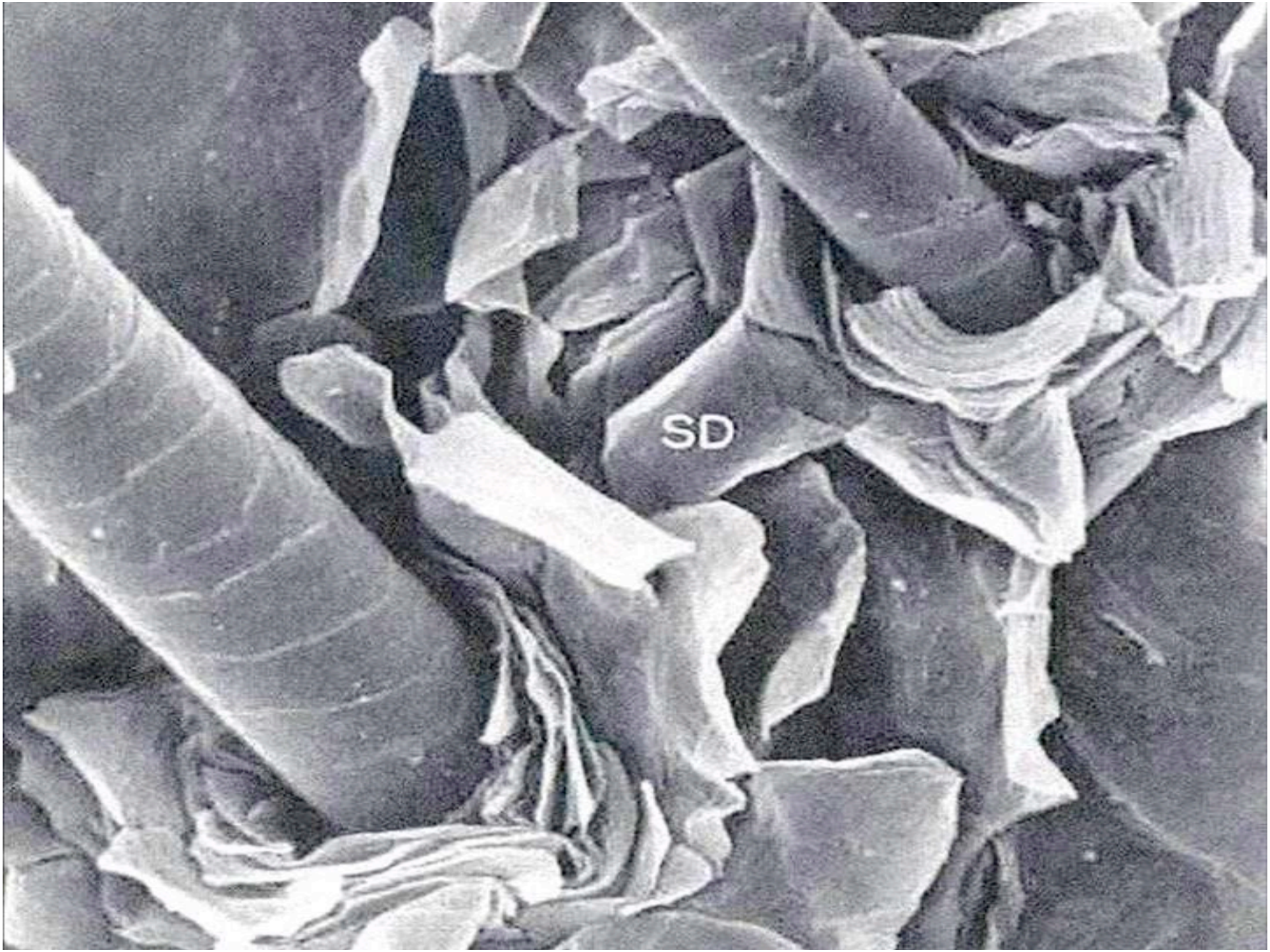
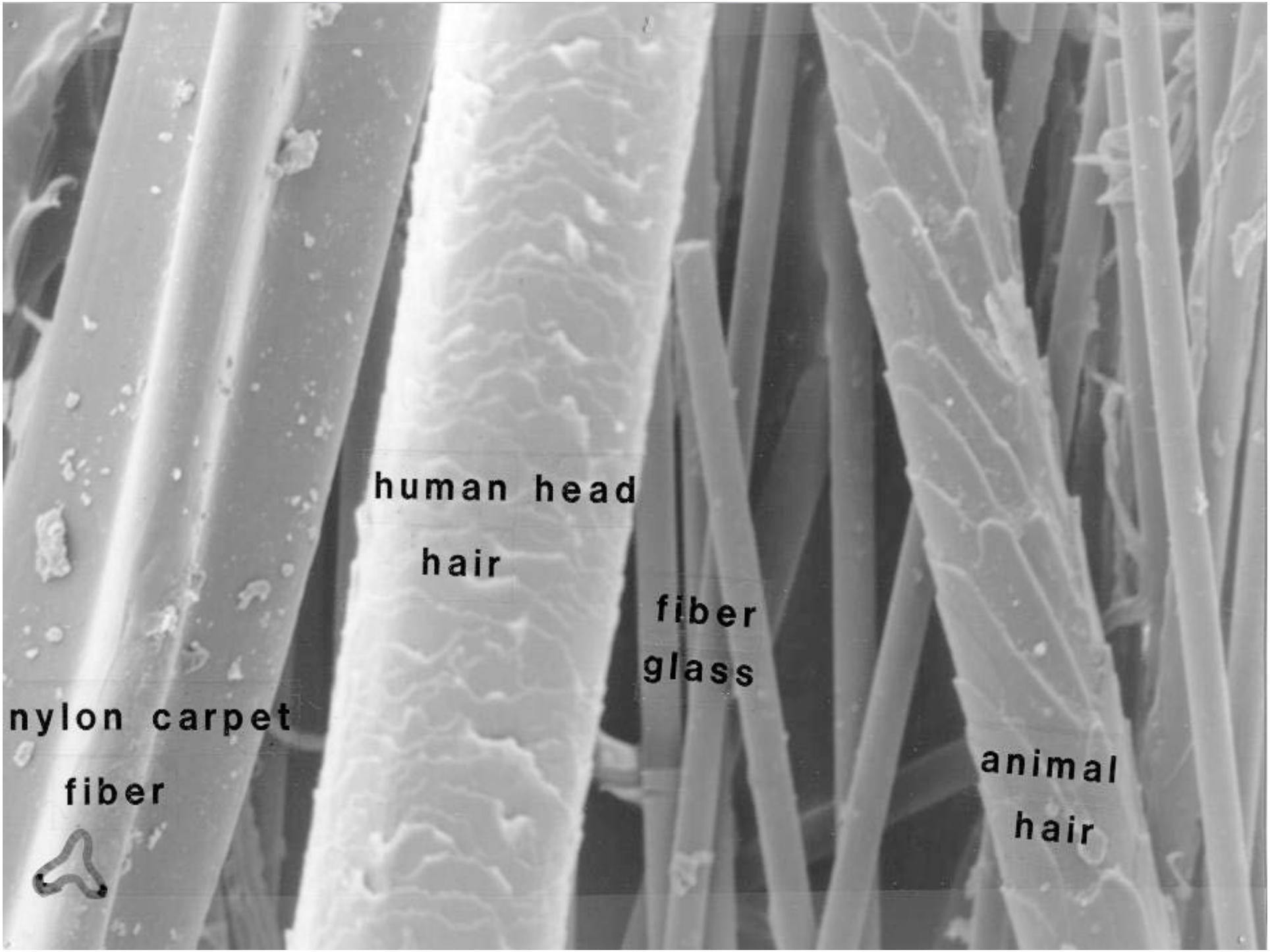

Hair Analysis


SD

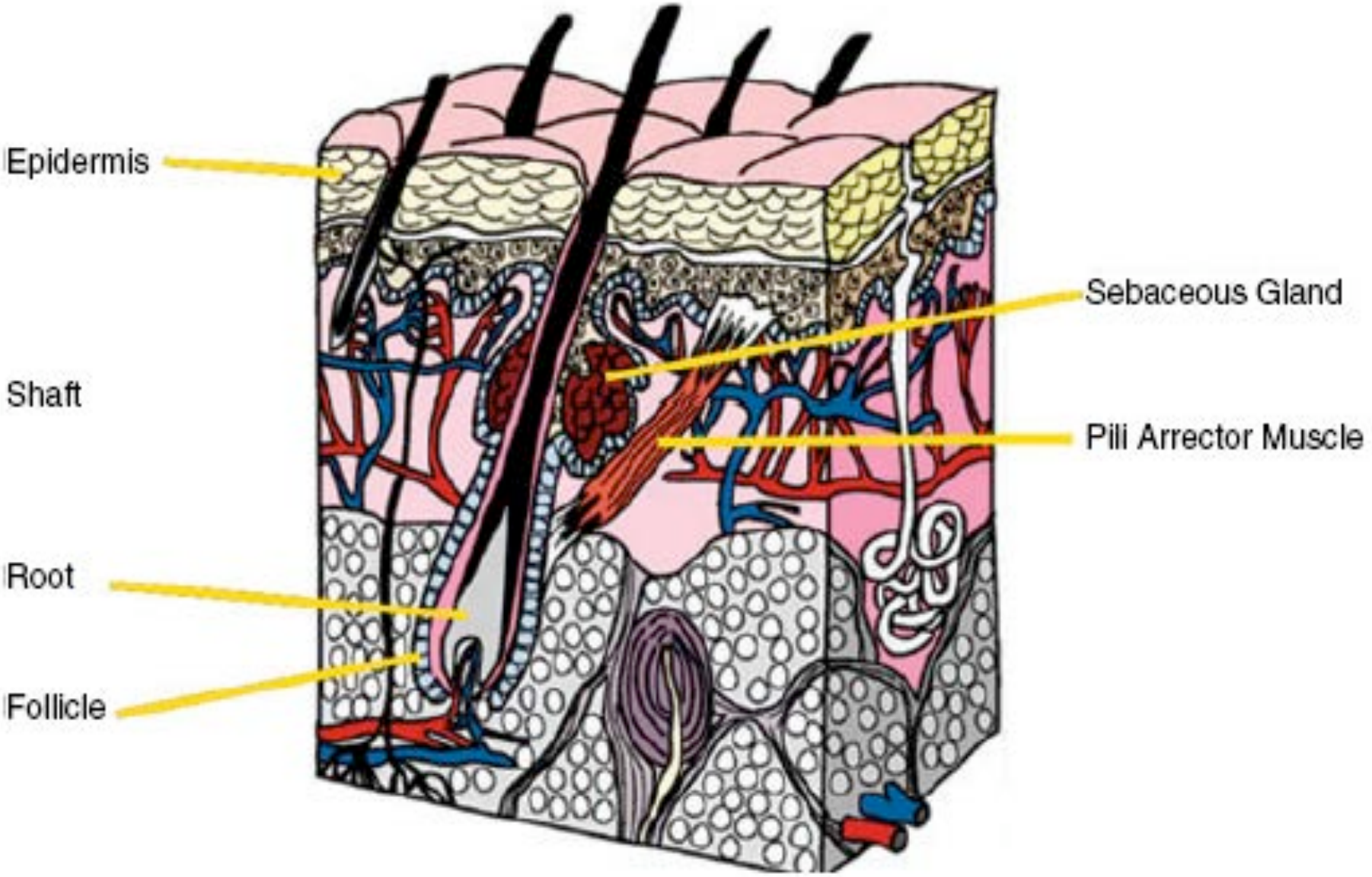
Microscopic Examination of Trace Evidence

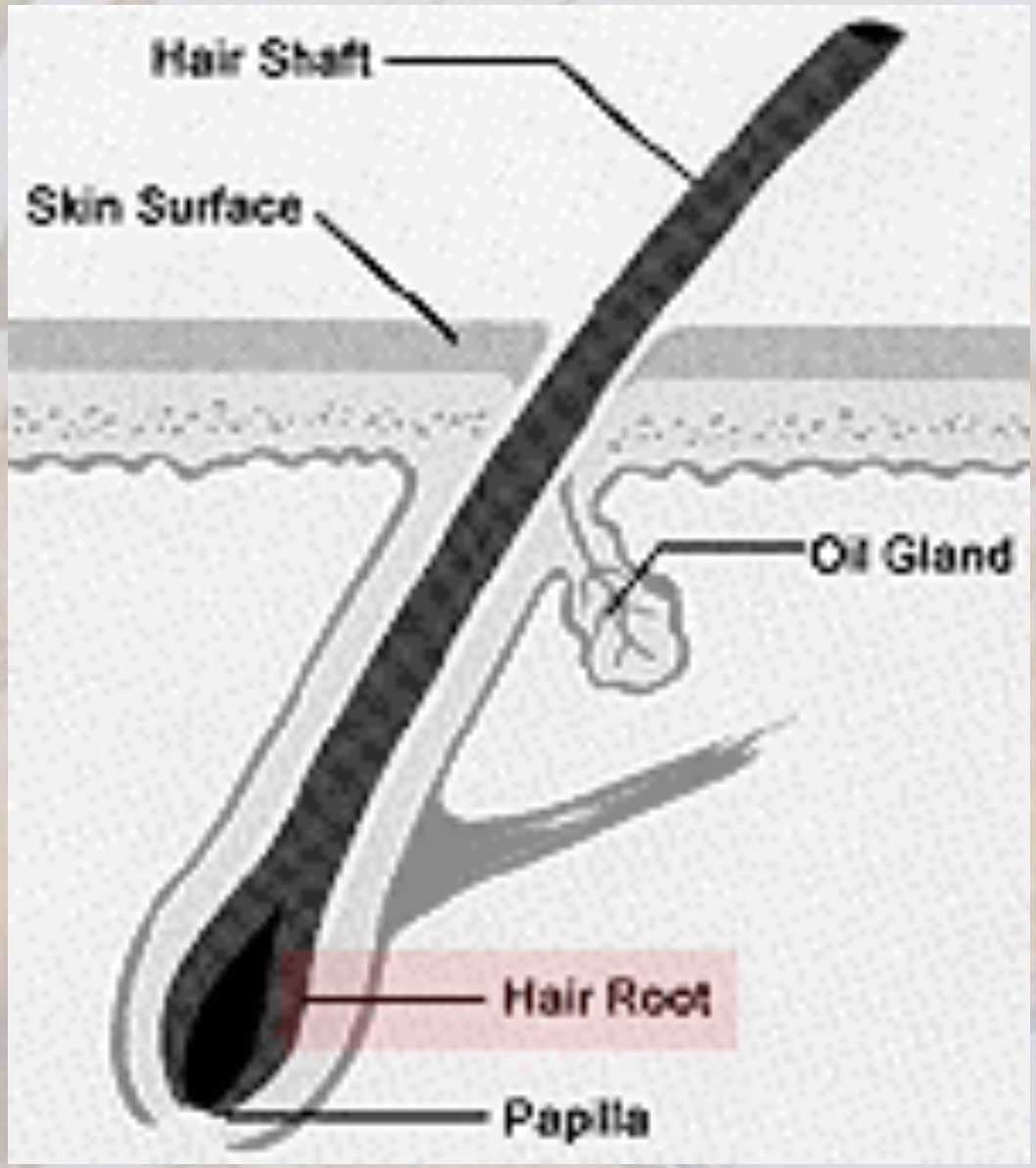
When a forensic scientist receives hair and/or fiber evidence from a crime scene they must determine the following things:

- **Is it a hair or is it a fiber?**
- **If a hair, is it animal or human?**
- **If animal, what species?**


human head
hair
fiber
glass
nylon carpet
fiber
animal
hair

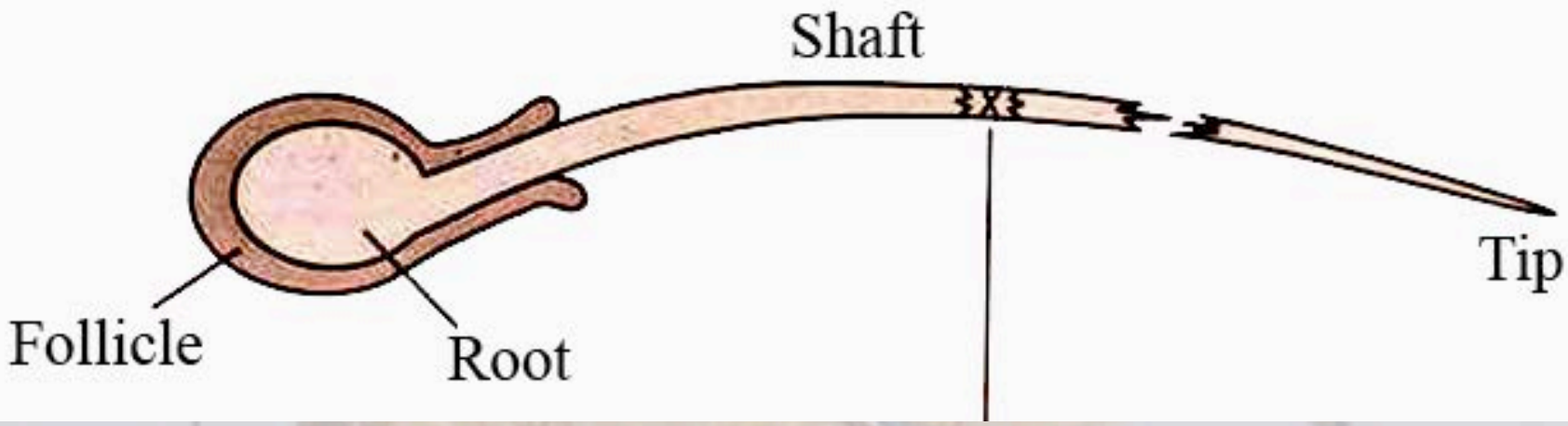
Cross Section of Skin containing Hair Follicles



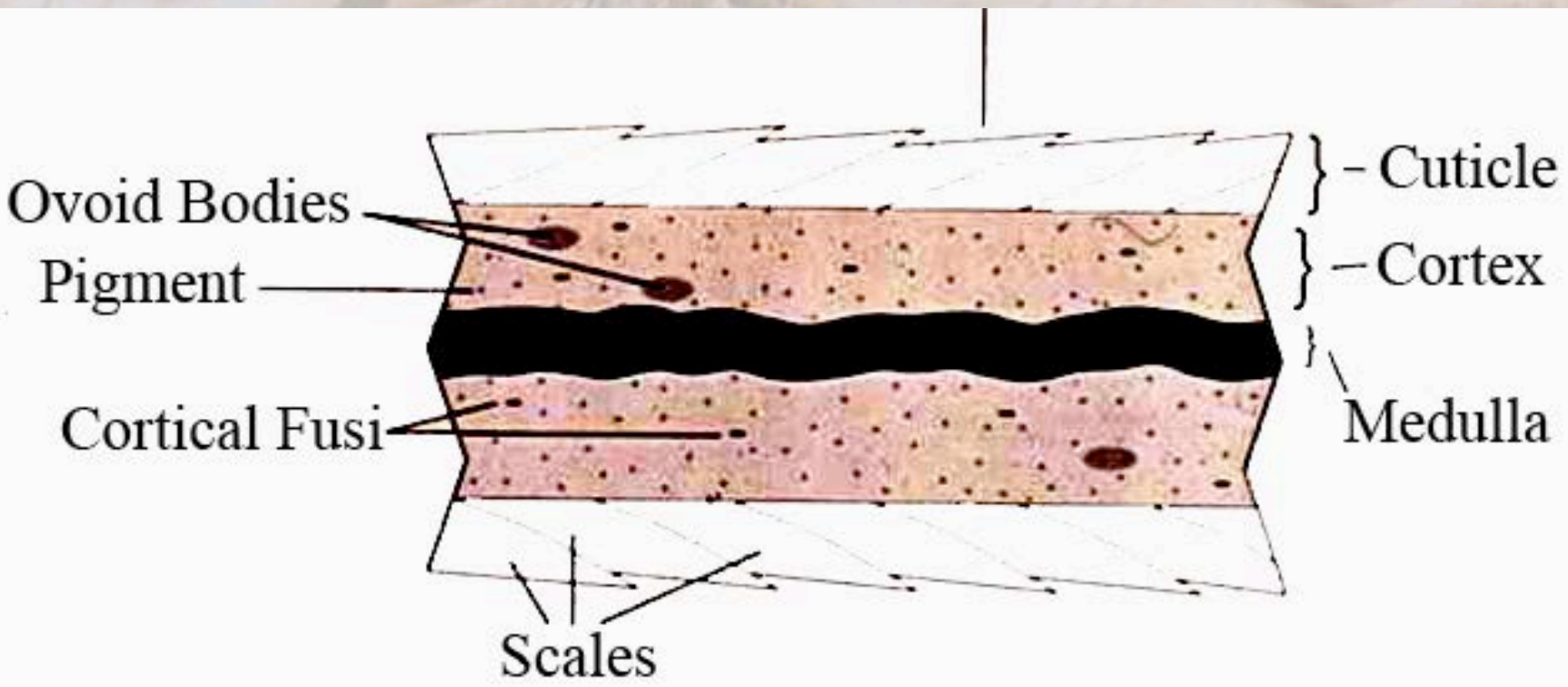

Hair Shaft
Skin Surface
Oil Gland
Hair Root
Papilla

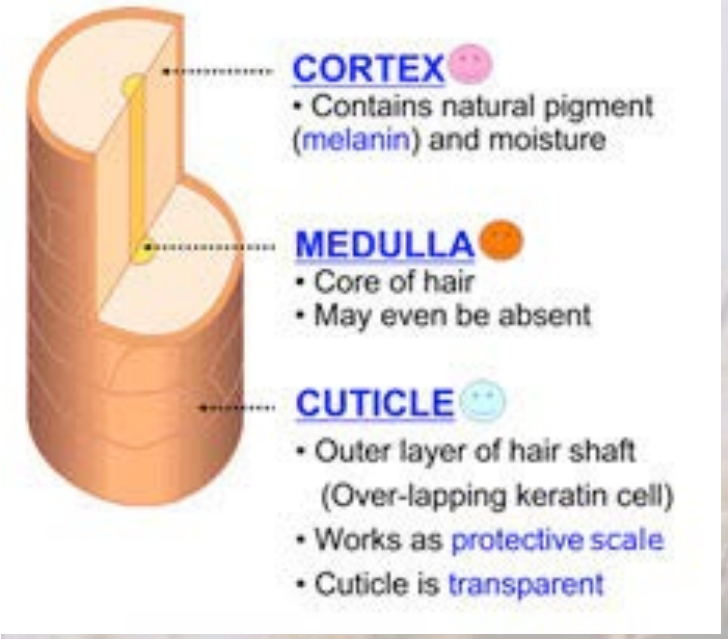
Hair Shaft is Composed of Three Layers:

1. Cuticle
2. Cortex
3. Medulla



Hair Shaft

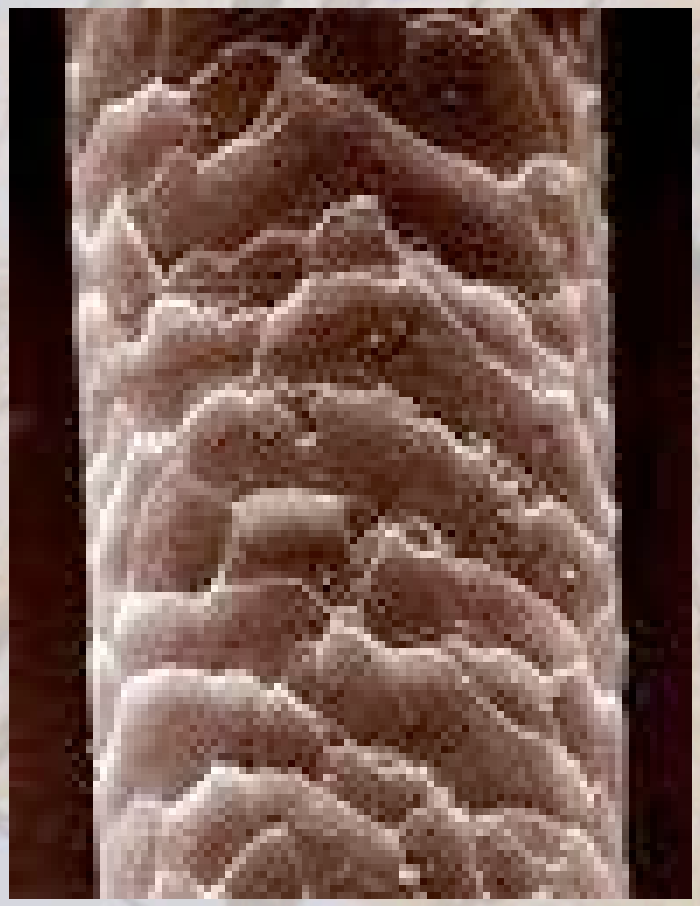

Ovoid Bodies
Pigment
Cortical Fusi
Scales
Cuticle
Cortex
Medulla

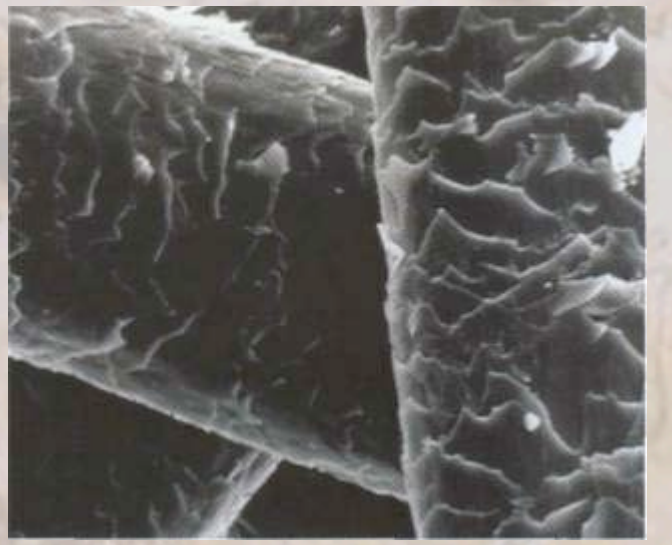


Cuticle

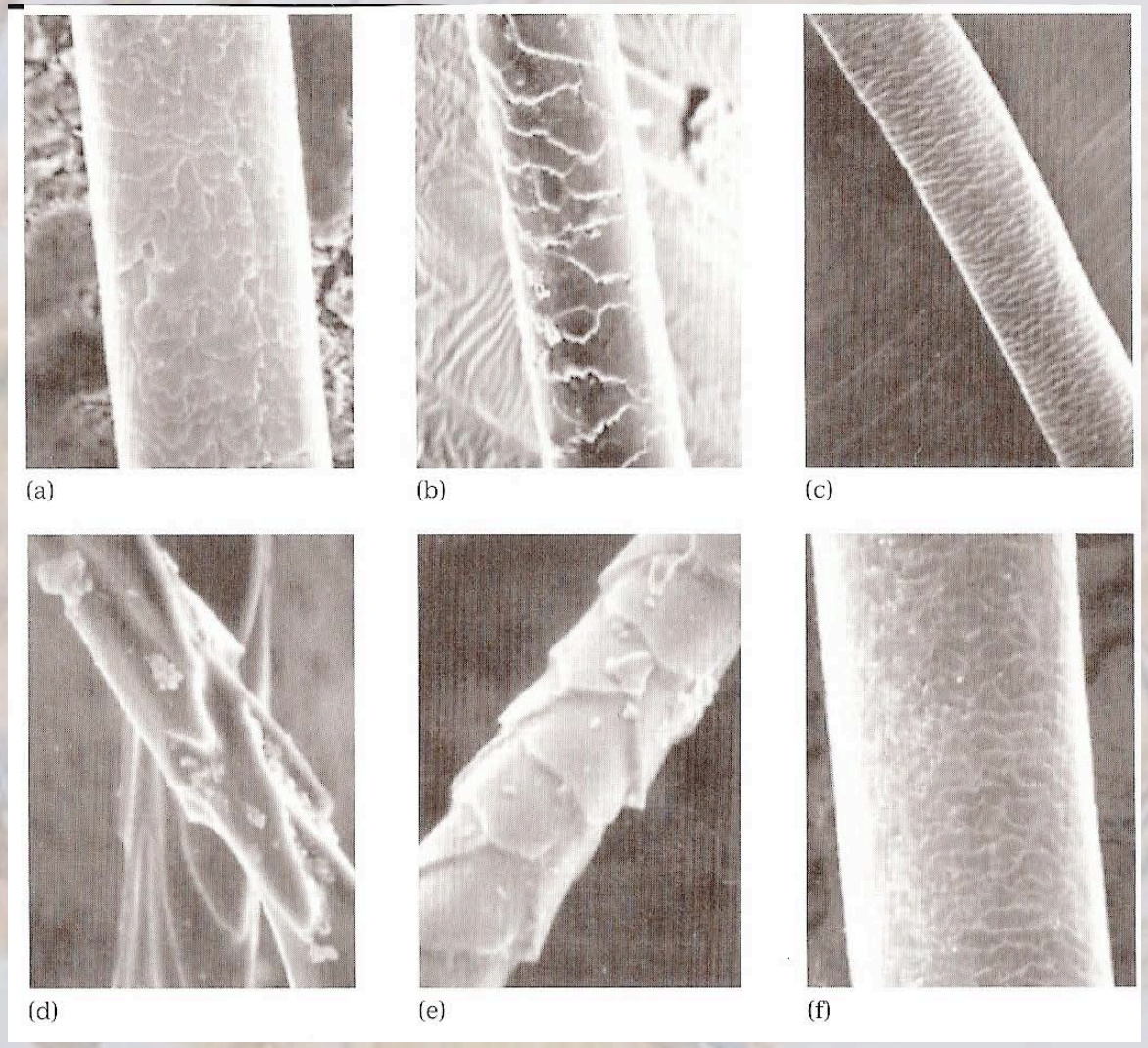
- Scale structure covering the exterior of the hair.
- Formed by overlapping scales that point toward the tip end of each hair.
- Produces a characteristic pattern
- Not useful in individualizing human hair
- Can be used for species identification

Hair Scales

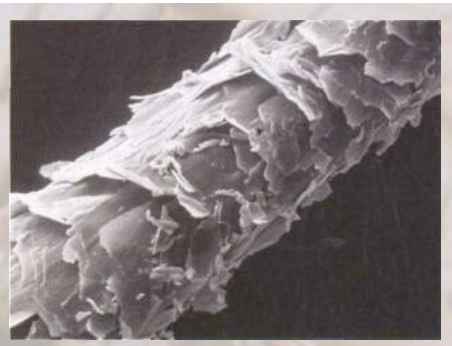


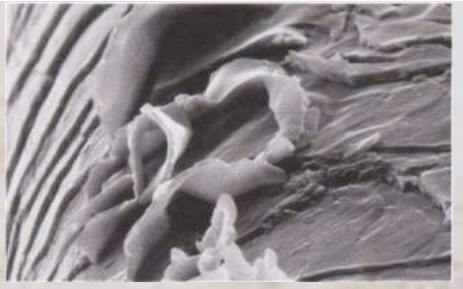


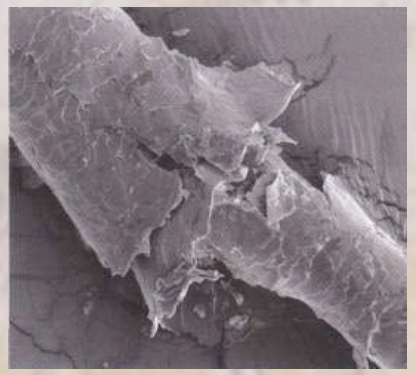
Variety of scale patterns helps to identify species!

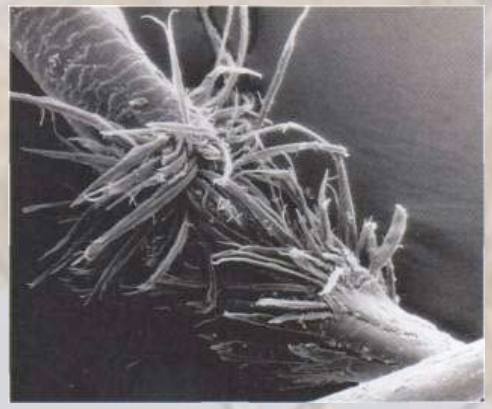


Damaged Hair









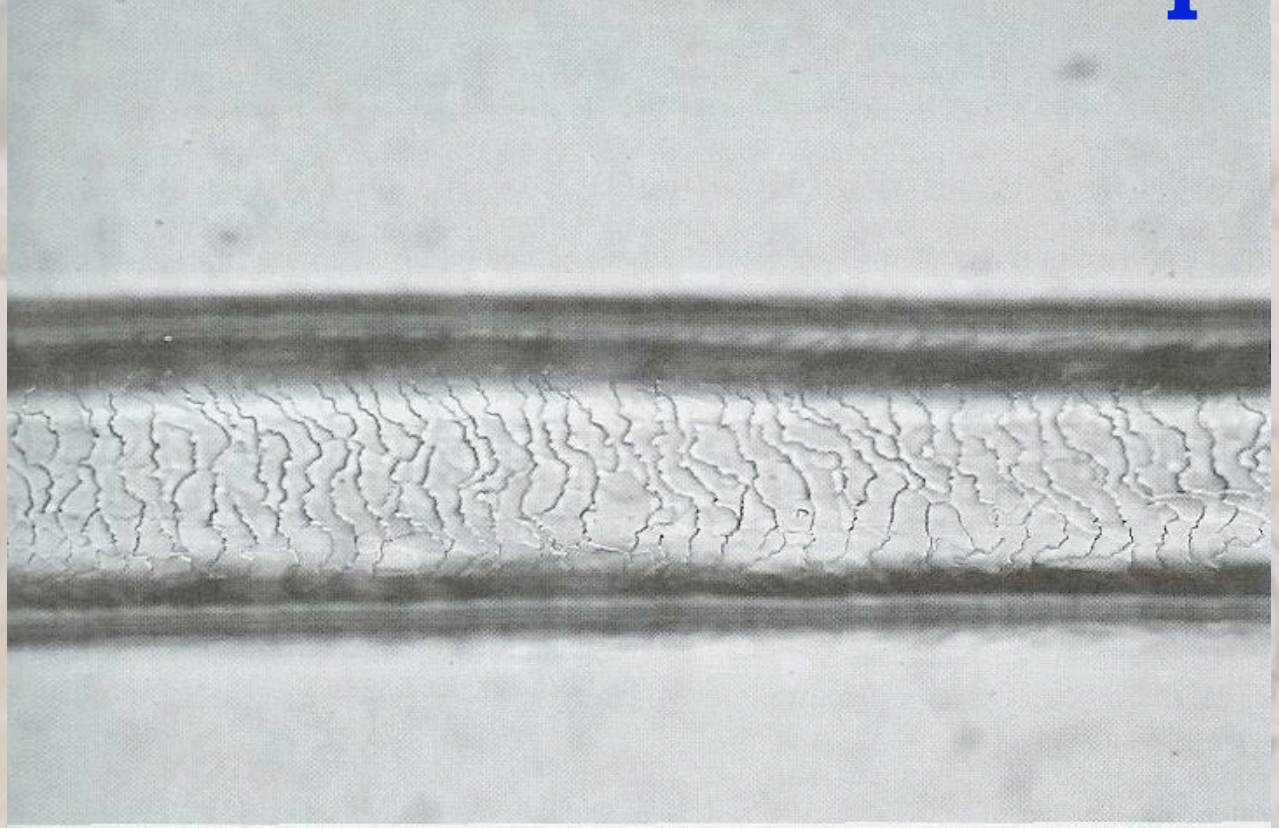
How can forensic scientists study the scale pattern of hair?

Make a Cast!

HOW???

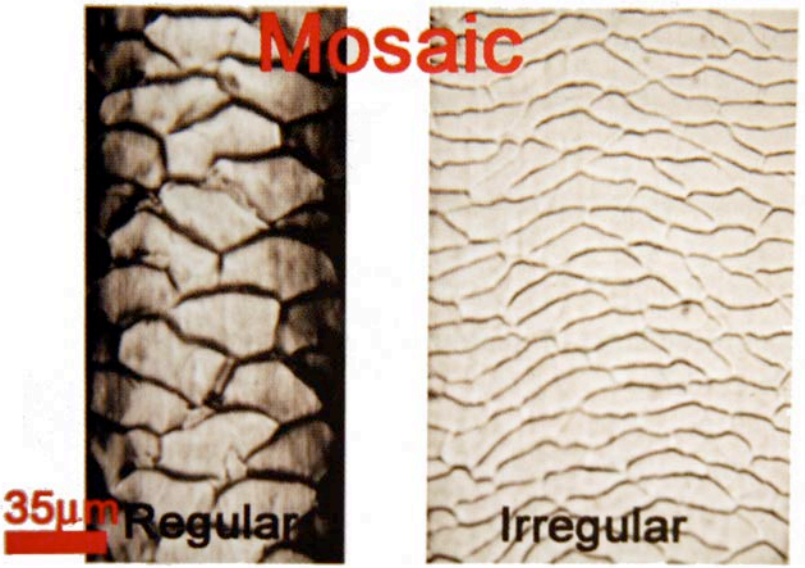
Embed hair in a soft medium, such as clear nail polish. When medium has hardened, hair is removed, leaving a clear, distinct impression of the hairs' cuticle.

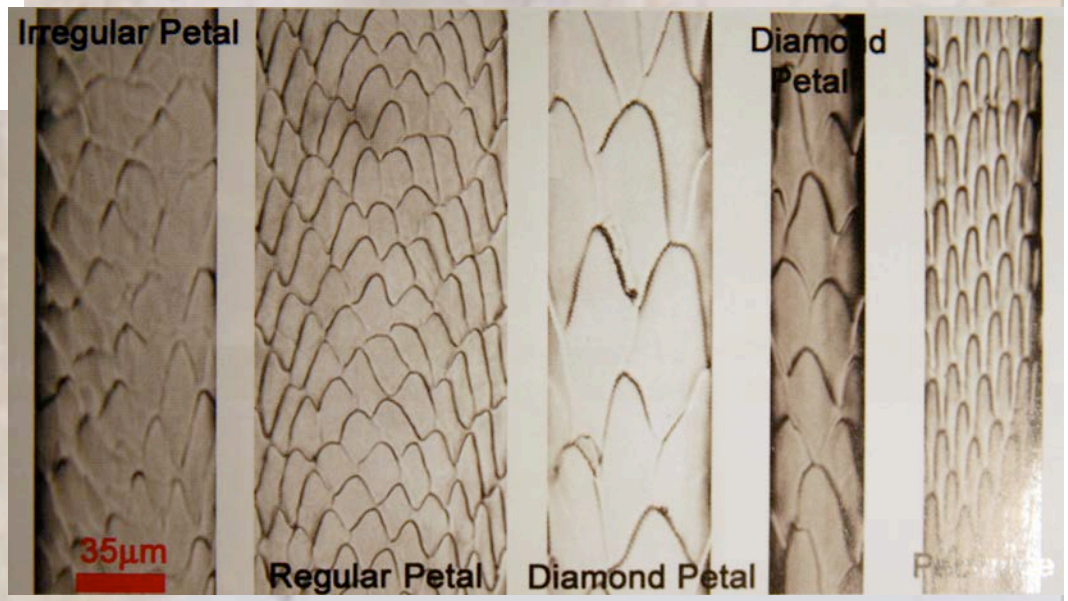
This is similar to what YOU will see under the microscope!



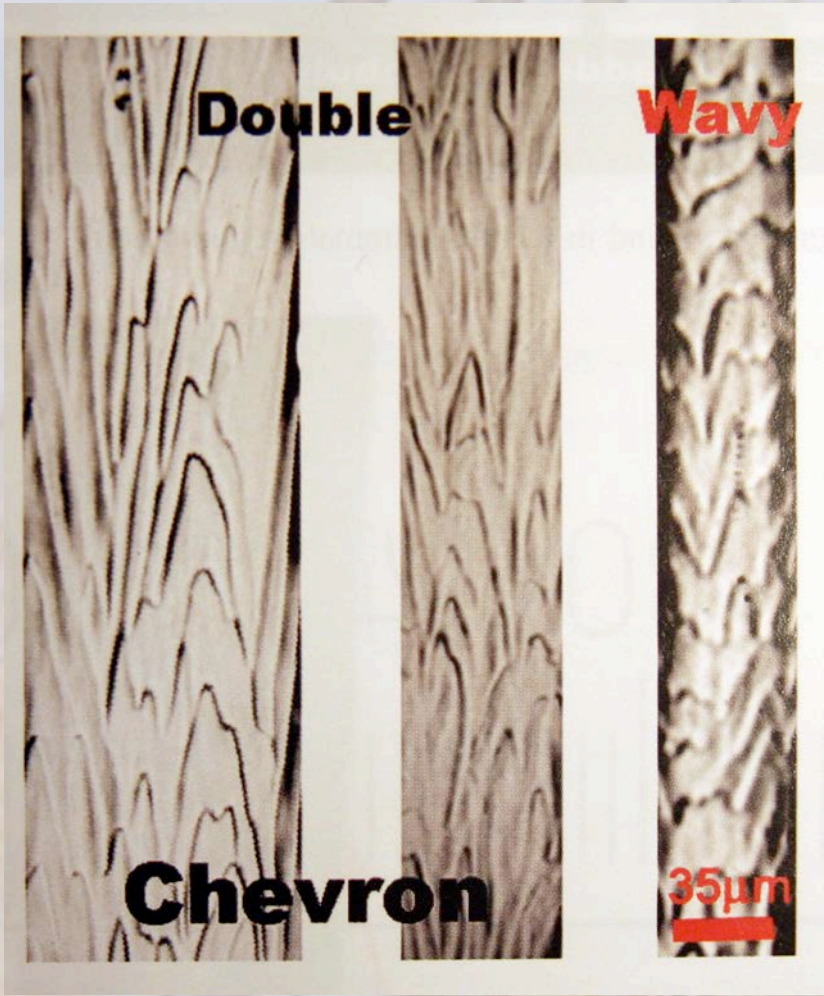
gure 3.2 A scale cast obtained from the shaft of a human scalp hair

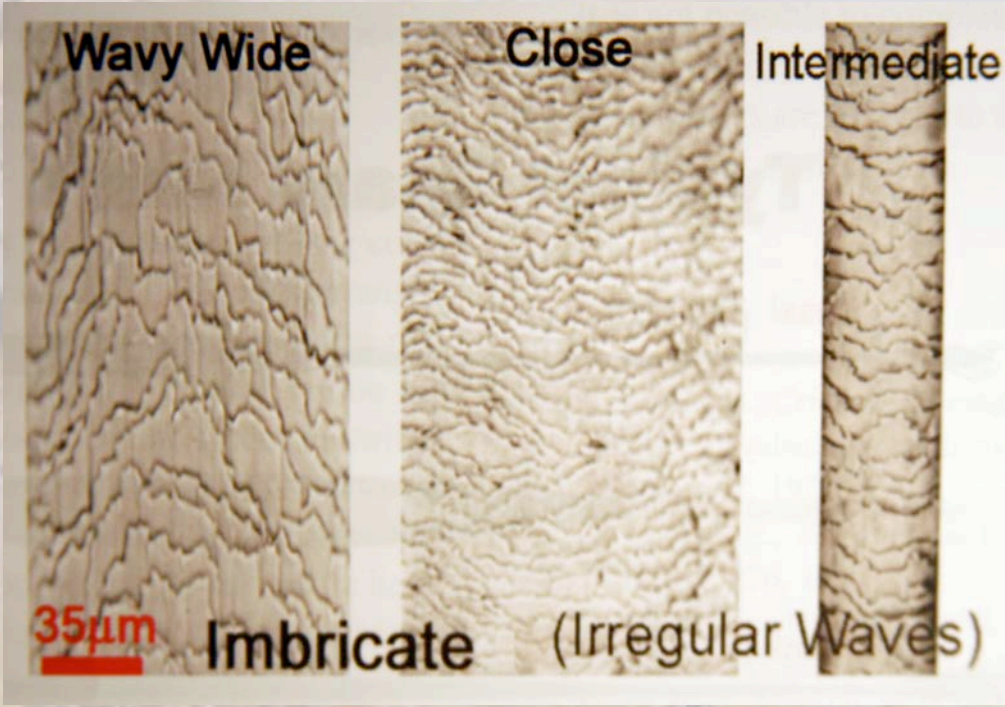
Scale Casts


Mosaic
35µm
Regular
Irregular


Irregular Petal
35µm
Regular Petal
Diamond Petal
Petal

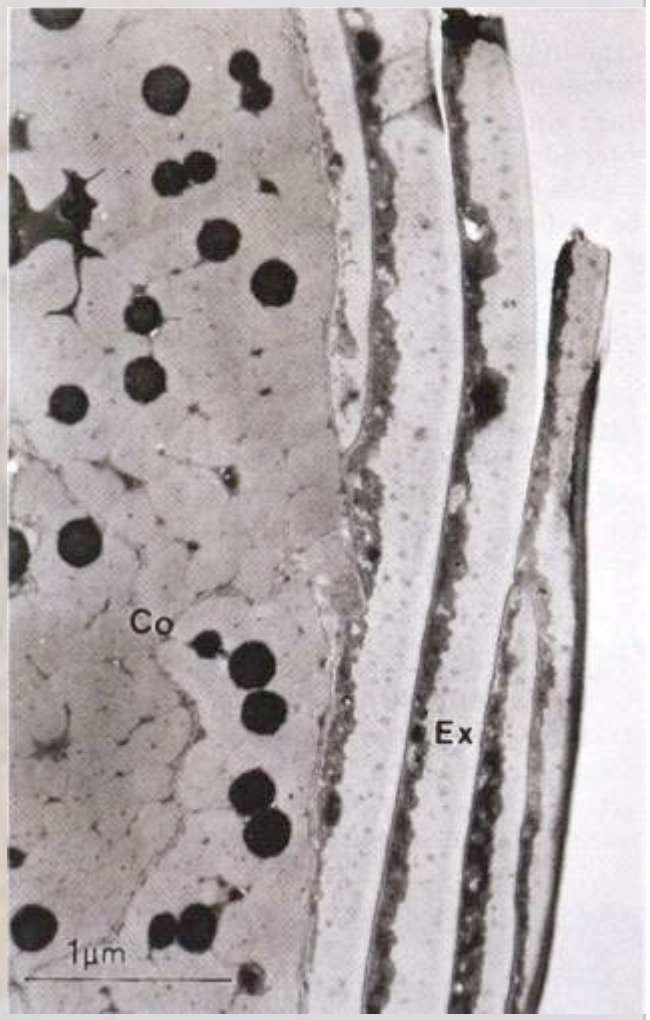
Scale Casts


Double
Wavy
Chevron
35µm


Wavy Wide
Close
Intermediate
35µm
Imbricate
(Irregular Waves)

Cortex

- Made of spindle-shaped cells aligned in a regular array, parallel to the length of the hair
- Embedded with pigment granules that give hair its color
- The color, shape and distribution of the granules provide points for forensic comparison



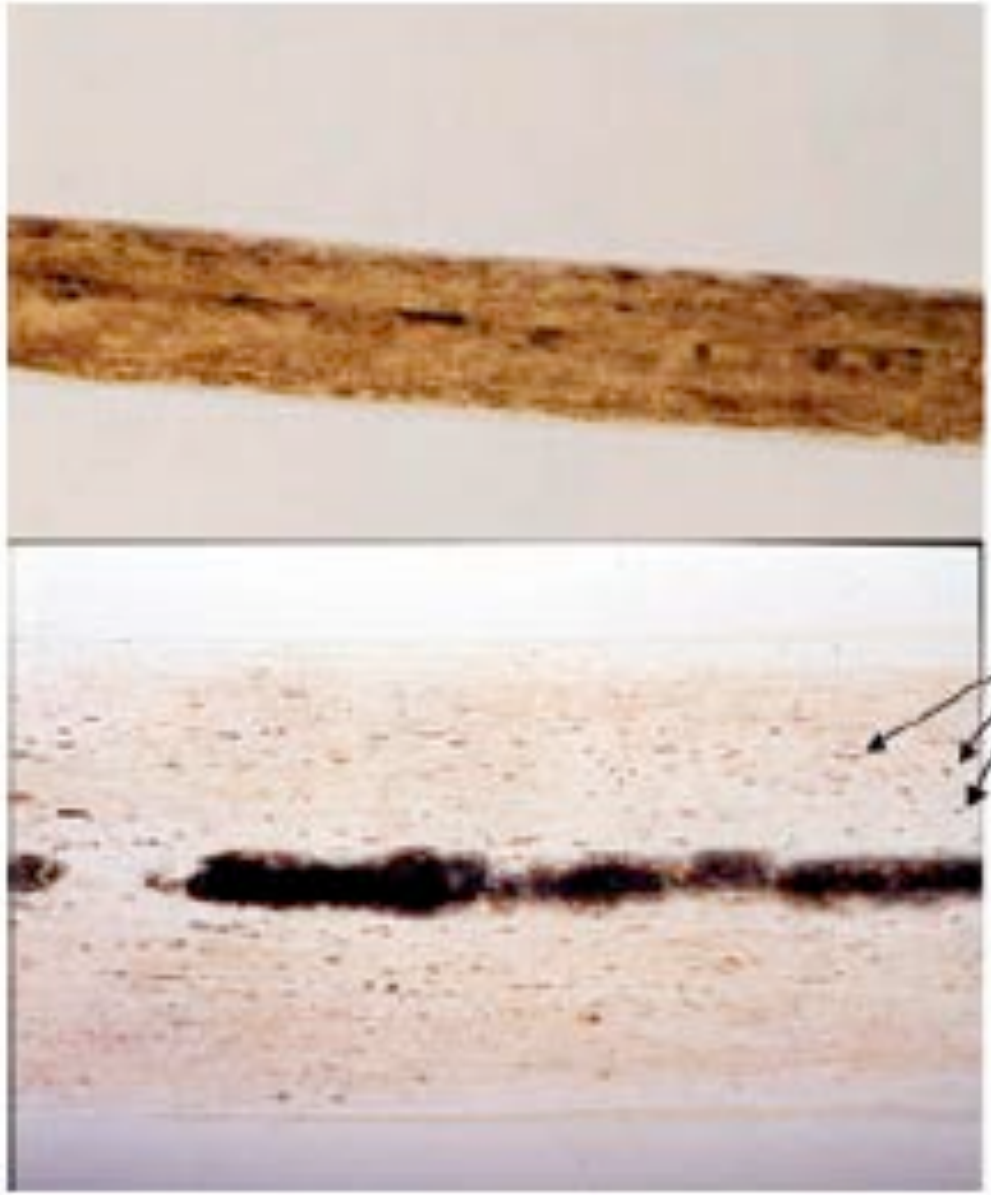
Hair Pigmentation

Melanocytes are the cells responsible for hair color

- **They produce Melanin**

Humans have only two kinds of hair pigments-

- ***eumelanin***
  - **(browny-red/ black pigments)**
- ***phaeomelanin***
  - **(yellow-red)**

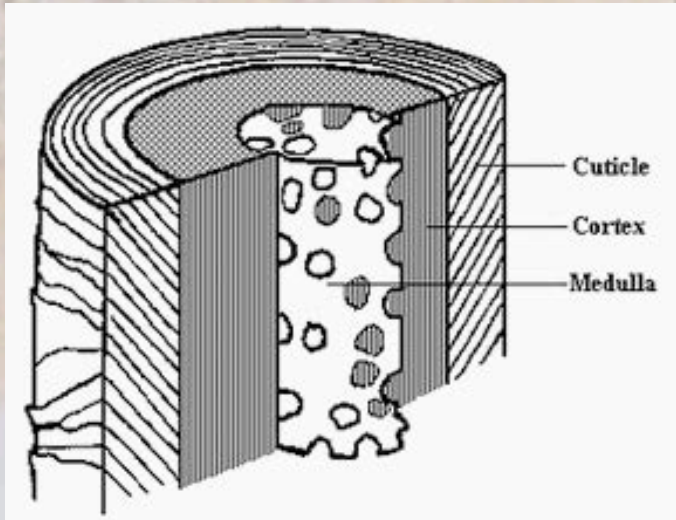

Pigmentation
Cortical fusi

Medulla

Canal-like structure of cells that runs through the center of the cortex

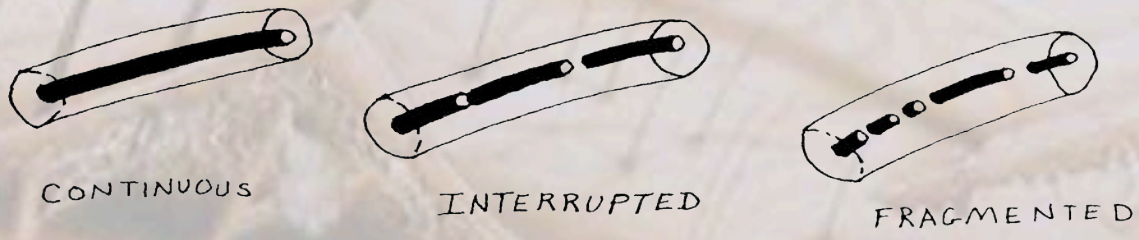
Forensic Analysis of:

- Structure (Appearance & Type)
- Shape
- Index



Medulla Structure

Appearance: continuous, fragmented, interrupted



- Most animals have a medulla that is continuous or interrupted
- Presence of medulla varies quite a bit: even hair to hair
- Human head hairs generally have no medulla or may be fragmented ones; except Mongoloid (Asian) race whose medulla is usually continuous

Medulla Structure

***Type*:**

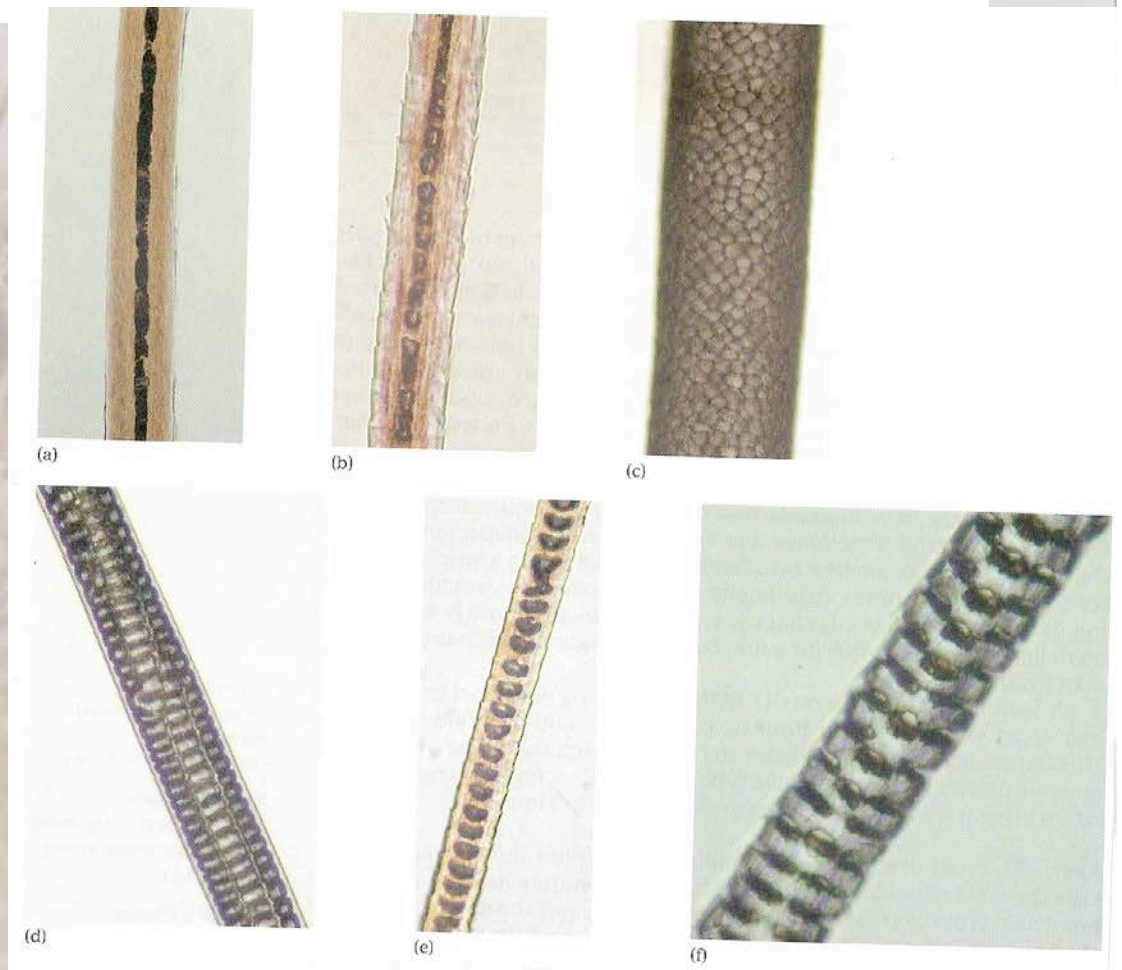
Uniserial (cat)

Multiserial (rabbit)

Vacuolated (dog, fox)

Lattice (deer)

Amorphous (human)



Medullary Index

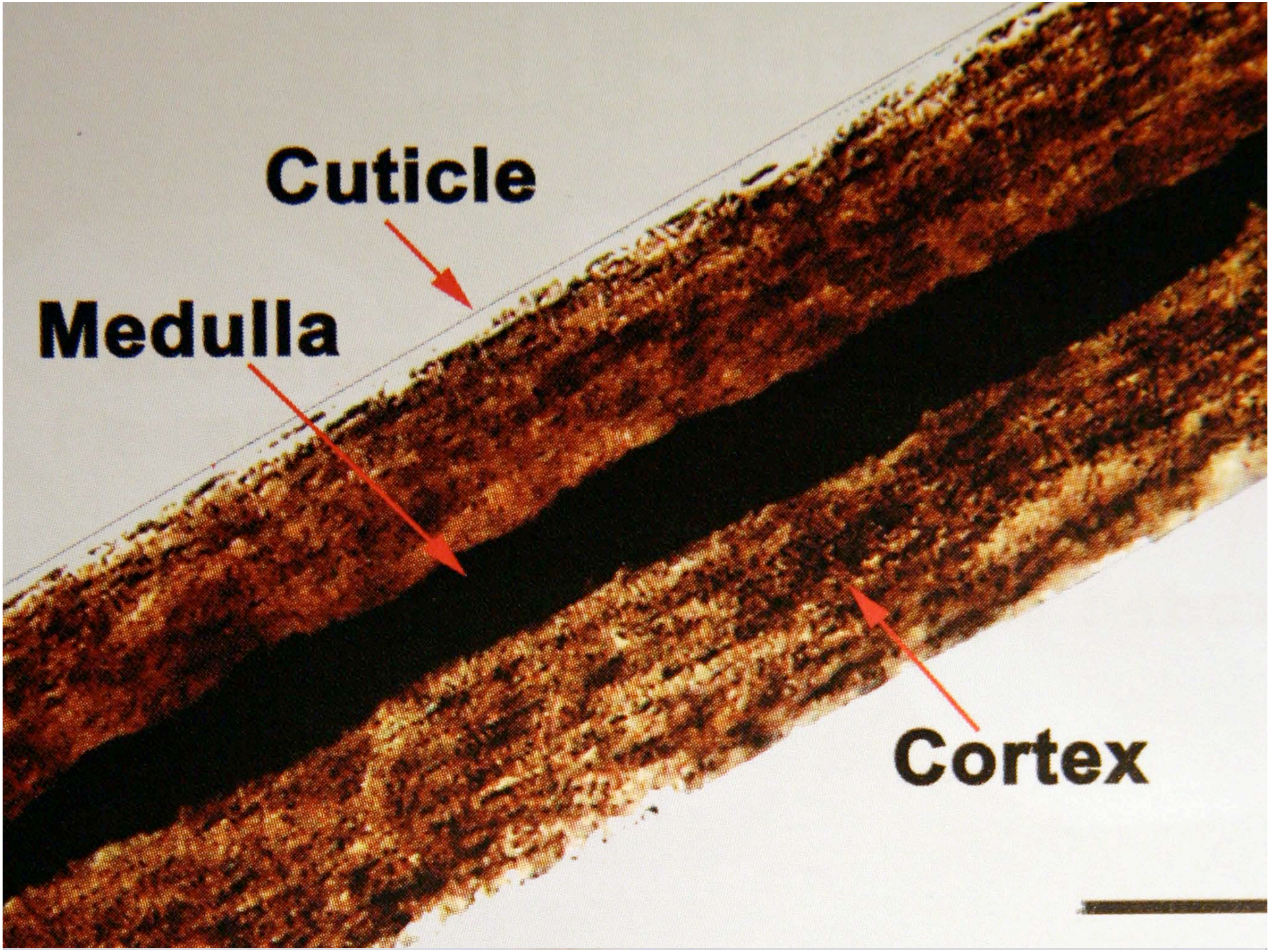
- Measure of the diameter of the medulla relative to the diameter of the hair shaft
- Usually expressed as a fraction
  - Humans: medullary index < 1/3
  - Animals: medullary index > 1/2

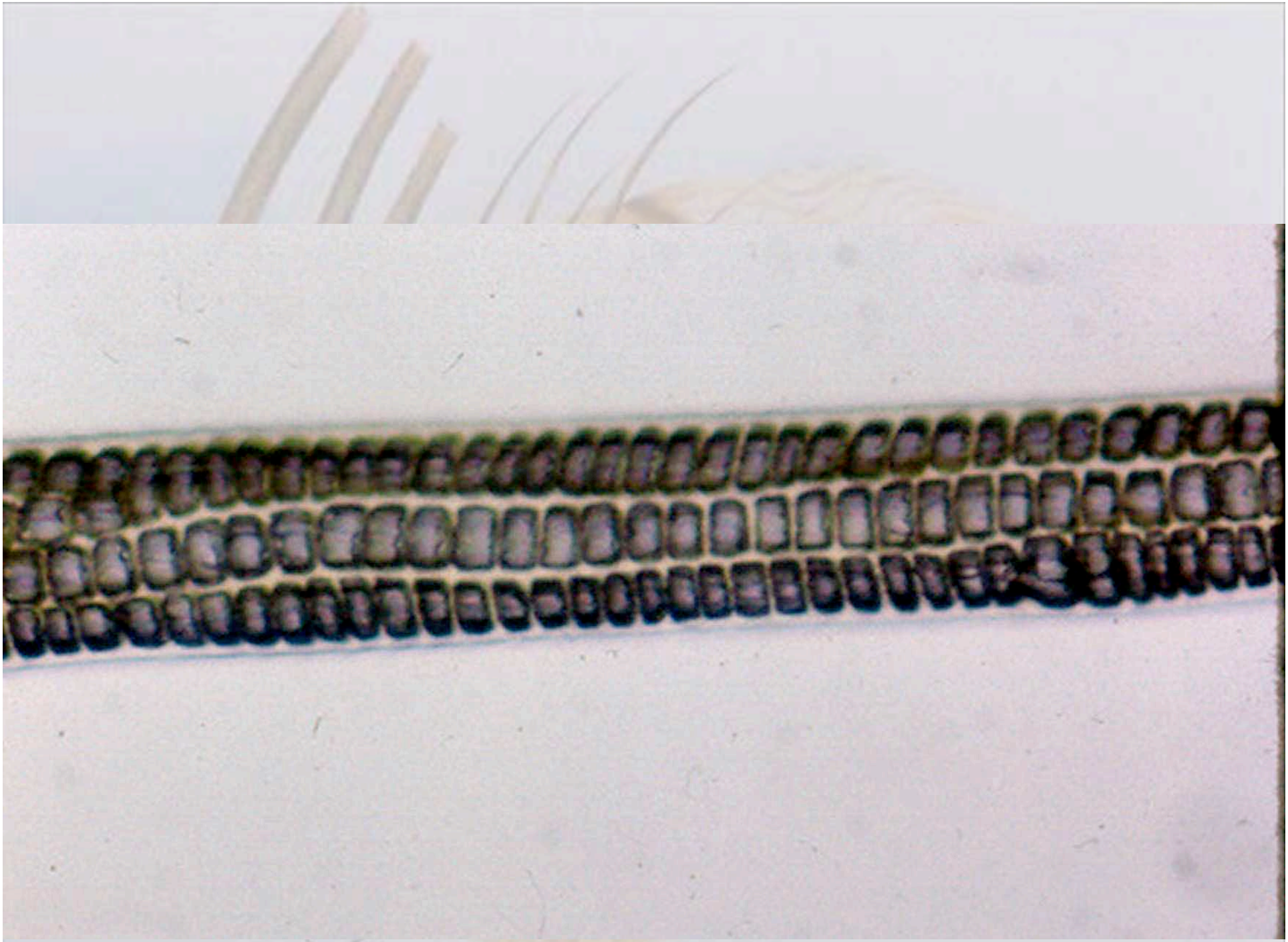
$$Medullary\ Index = \frac{\text{diameter of medulla}}{\text{diameter of hair}}$$

Medulla Shape

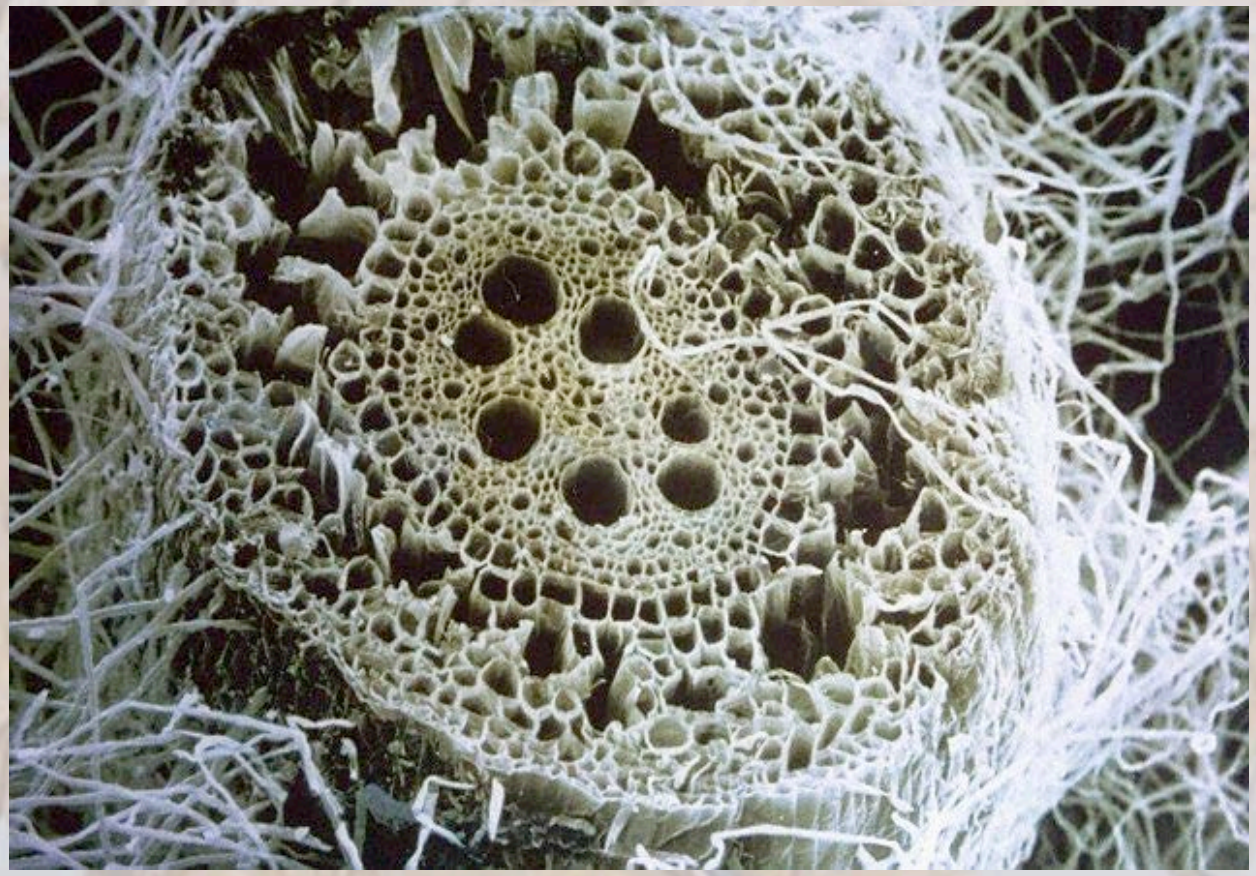
- The shape of the medulla can help identify a species

- Examples:
  - Most animals and humans: cylindrical
  - Cats: pearl shape
  - Deer: spherical occupying whole hair shaft


Cuticle
Medulla
Cortex



Scanning Electron Microscope: Hair Cross Section




Phases of Hair Growth

Growth Phases of Hair

- Anagen - actively growing phase
  - Follicle produces new cells
  - Cells in follicle produce melanin or pigment that impart color to hair
  - Root bulb - Flame shaped appearance
  - May last up to six years
  - Some hairs in anagen phase have a **follicular tag!**

Anagen
(growing)

What is a Follicular Tag?

- A translucent piece of tissue surrounding the hair shaft near the root.
- Richest source of DNA associated with hair.

Hairs – Forcibly Removed

ROOTS OF THREE
FORCIBLY REMOVED
HEAD HAIRS OF
CAUCASIAN ORIGIN

Human Hair Roots Suitable for Nuclear DNA Typing

Human Hair Roots Not Suitable for Nuclear DNA Typing

What do you notice???

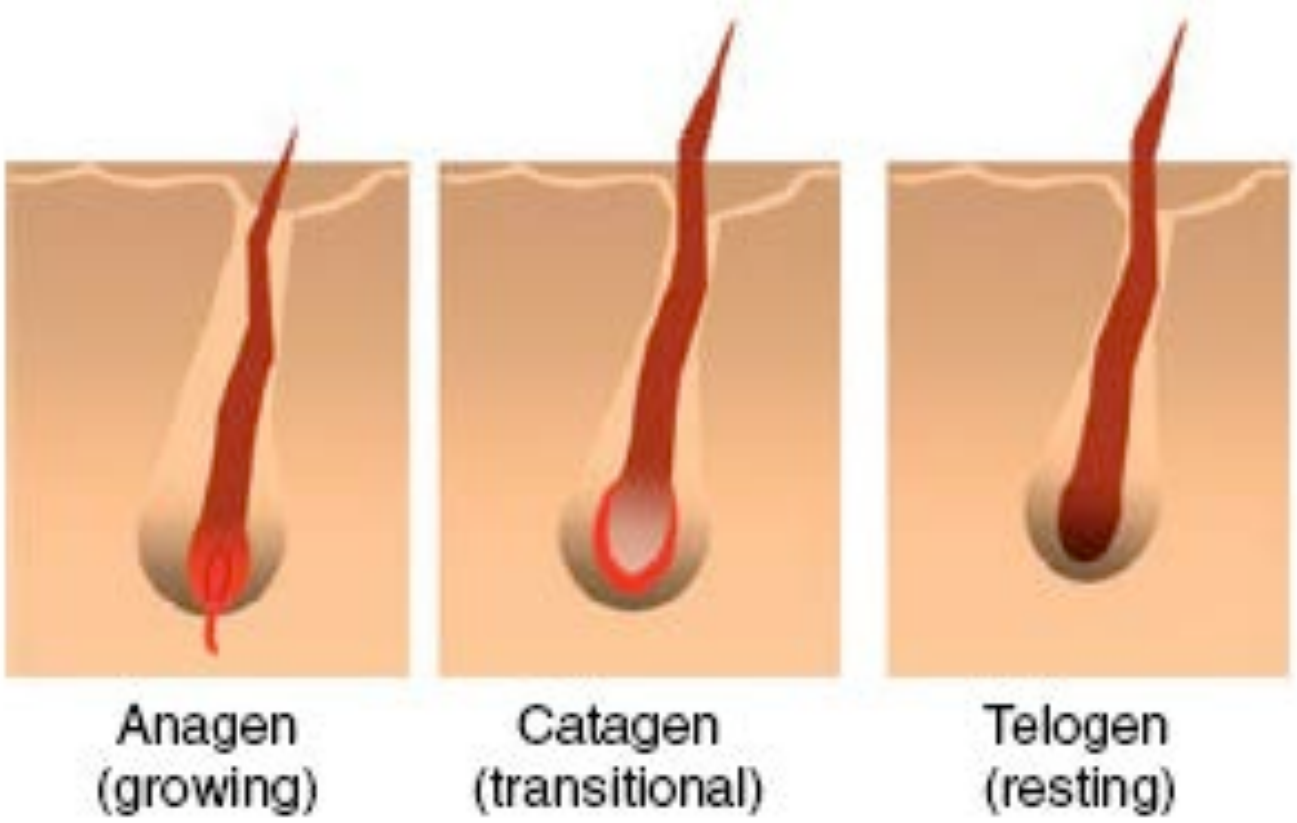
Growth Phases of Hair

- Catagen – transition to resting phase
  - Follicle begins to shut down cell production
  - Cells shrink (Root bulb begins to get pushed out of hair follicle.)
  - Root condenses (elongation)
  - 2-3 weeks

Growth Phases of Hair

- Telogen – resting phase
  - No cell production
  - Root - club-shaped appearance
  - Hair naturally falls out of skin
  - Over 2-6 months

Growth Phases of Hair



Identification and Comparison of Hair

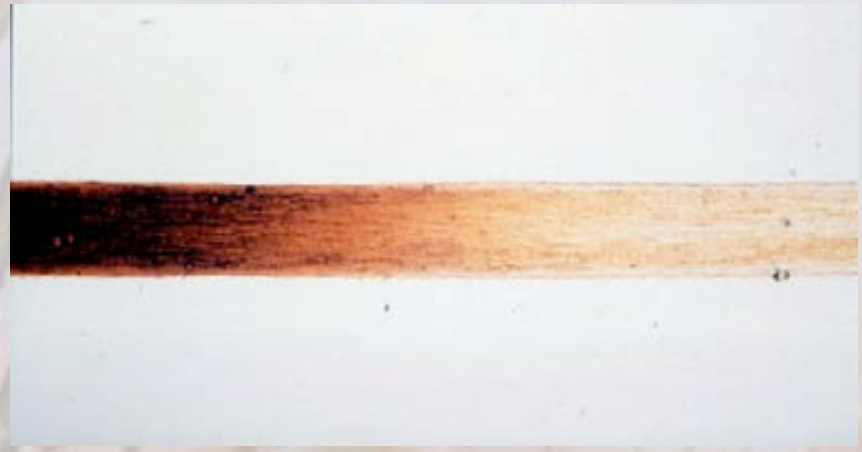
Examiner must have access to a comprehensive collection of reference samples and the examiner must have experience!

COMPARISON OF HUMAN HAIRS

- Most forensic hair examinations involve comparison of questioned hairs from a crime scene to a known hair sample
  - Known hair sample consists of 50-100 hairs from all portions of area of interest
  - Comparison microscope is used for examination

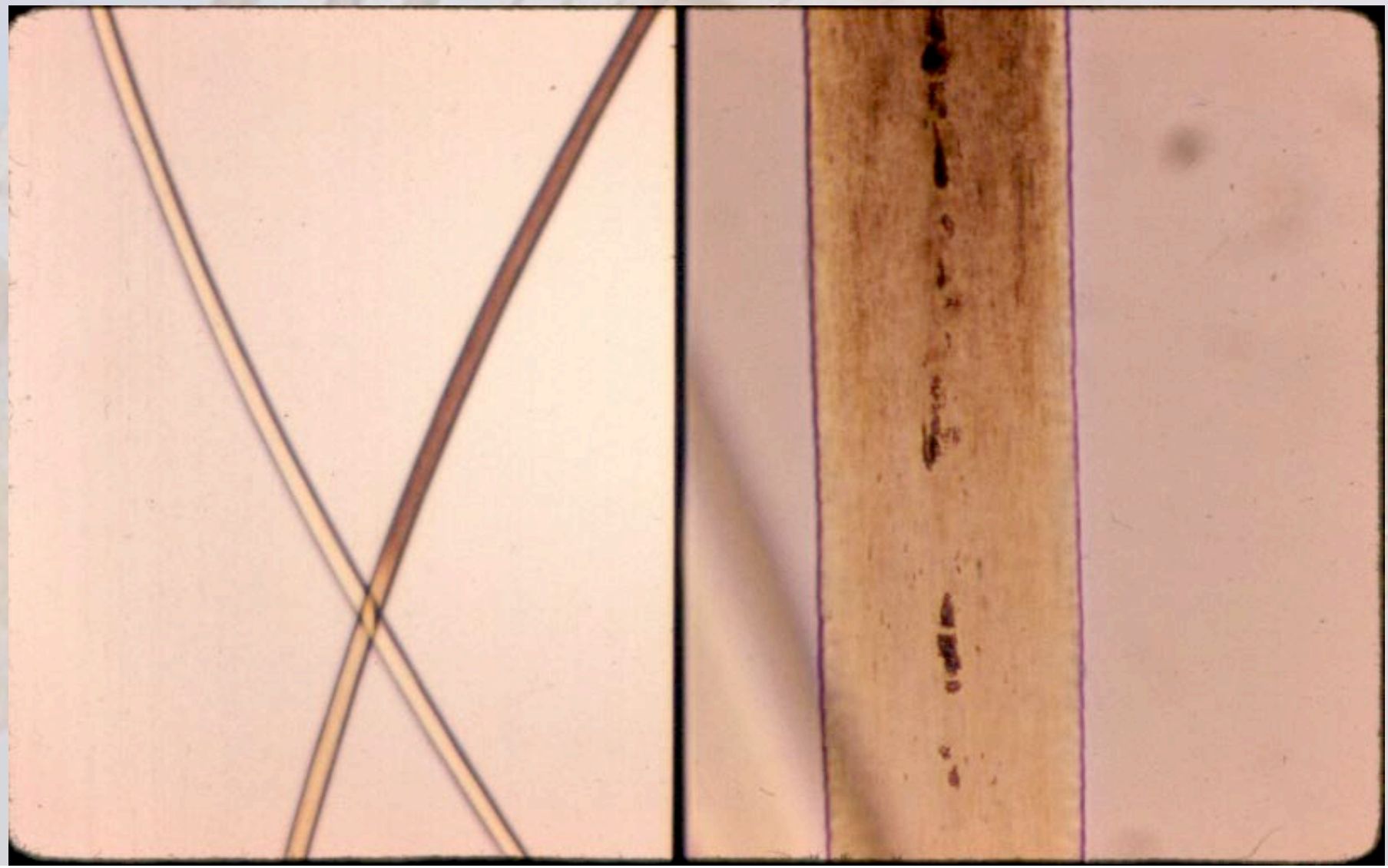
In comparing hair, the forensic scientist matches:

- Color
- Length
- Diameter
- Presence/absence of medulla
- Distribution, shape, and color intensity of pigment granules
- Dyed or bleached hair from natural hair
- Damage
- “Critters”




Singed
Split

Bleached Caucasian Head Hair



Forensic Hair Examination

Can a Body area from which a Hair Originated be Determined?

- Scalp Hairs
- Pubic Hairs
- Beard Hairs

Somatic Origin

Can Racial Origin of Hair be Determined?

- Caucasian - normally straight or wavy, very fine to coarse pigments that are more evenly distributed. Oval to round cross section.
- Negroid - normally kinky, dense unevenly distributed pigments. Flat to oval cross section.
- Mongoloid - Continuous medulla. Round cross section.

Racial Origin Determination

Mongoloid

Pigment granules larger than Caucasoid and grouped in patchy areas within shaft

Caucasoid

Fine-medium sized evenly distributed pigments

Negroid

Largest pigment granules, grouped in clumps of different sizes and shapes

Can the Age and Sex of an Individual be determined from a hair sample?

- Age - only infant hair!
- Presence of dye may offer some clue, BUT…
- Must obtain **nuclear DNA** to determine sex.

Where?

Can Human Hair be Individualized?

YES!!!

- Analyzing nuclear DNA - DNA present within the nucleus of the cell. Inherited from both parents. **What is needed???**
- Which **phase** of hair growth is best for determining the likelihood of successful DNA typing?

What if the hair does not have adhering tissue or root structure?

Alternative

- Mitochondrial DNA - DNA present in small structures outside the nucleus. (MATERNAL)
- Hairs 1-2 cm long
- Can not individualize hairs analyzed using mitochondrial DNA
- Can exclude certain people!

Hair Analysis: Positive ID

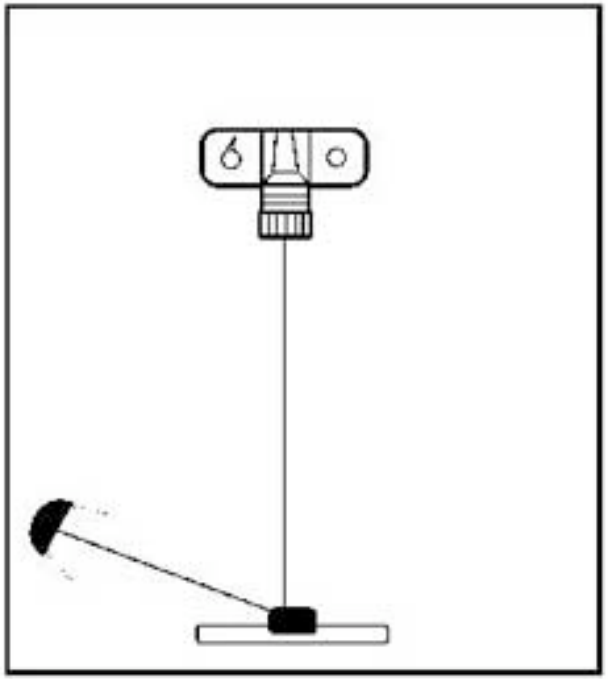
- **Hairs do not possess a sufficient number of unique individual microscopic characteristics to be positively identified as having originated from a particular person to the exclusion of all others.**
- **Microscopic consistency is presumptive**
- **DNA is confirmatory**

Collection and Preservation of Hair Evidence

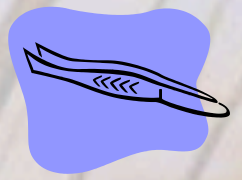
Oblique Lighting

- **Oblique lighting uses a light source at a low angle, usually to show detail by creating shadows in the subject surface. It is commonly used when photographing impressions, tool marks and certain types of fingerprints.**

Searching Methods



Collection of Hairs



- Tweezers
- Specialized vacuum cleaner
- Scraping
- Combing
- Tape Lifting
- Gel Lifters
- Virginia Police (post-its)

Packaging of Trace Evidence

Druggist's Fold

- **Large and Small**