Hair, Fiber, Scars, Tattoo marks

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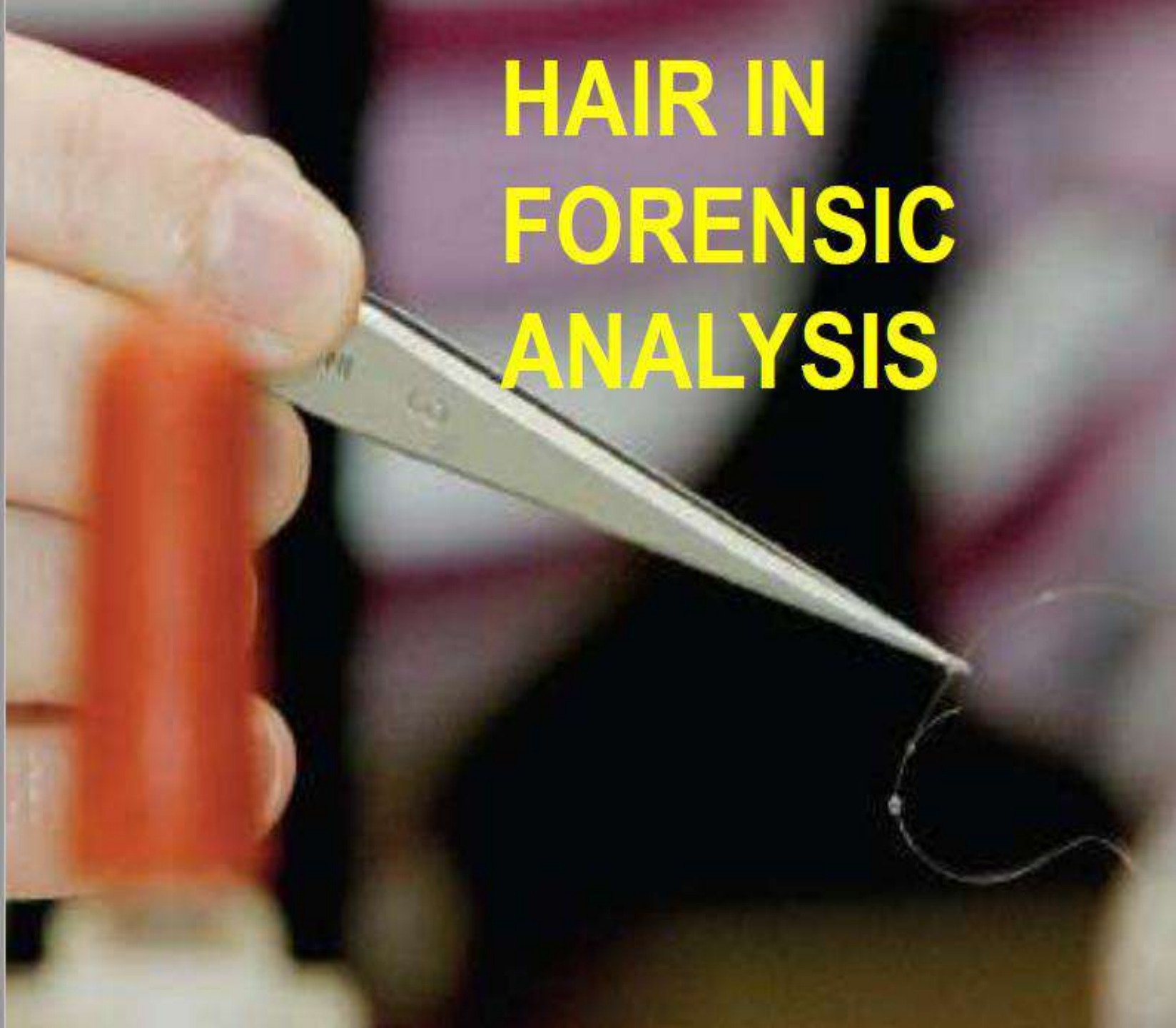

HAIR IN
FORENSIC
ANALYSIS

Hair

- Study of hair is known as trichology.
- Its application for administration of law and justice is known as forensic trichology.
- Composition –

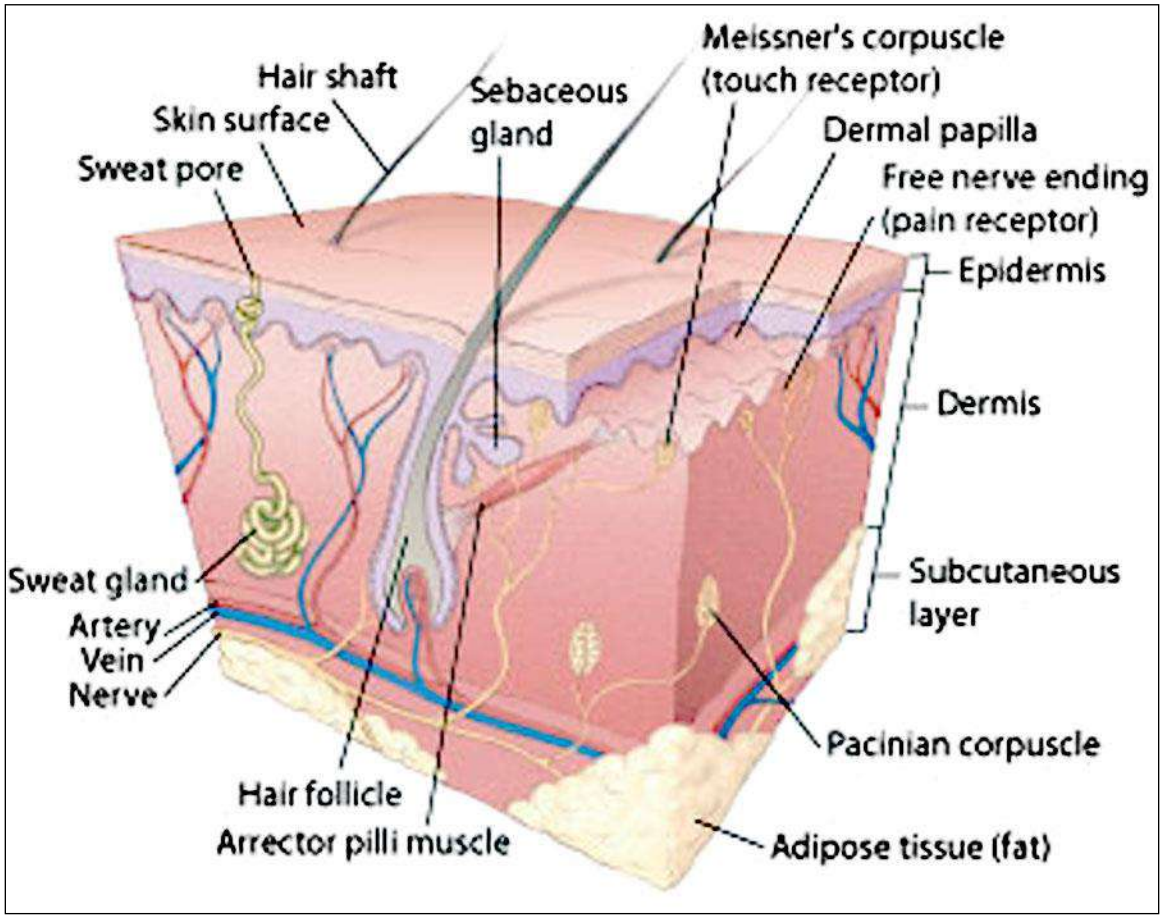
- Protein (65-90%)
- Water (15-35%)
- Lipids (1-9%)

- Growth – occur in 3 phases

a. Anagen or growing phase – lasts for 2-7 yrs for scalp hair, 4-7 months for eyebrows and other body parts
b. Catagen or resting phase – lasts for 2-3 weeks for scalp hair, 3-4 weeks for eyebrow and other body part
c. Telogen or shedding phase – lasts for 3 months for scalp hair , 9 months for eyebrow and other body parts

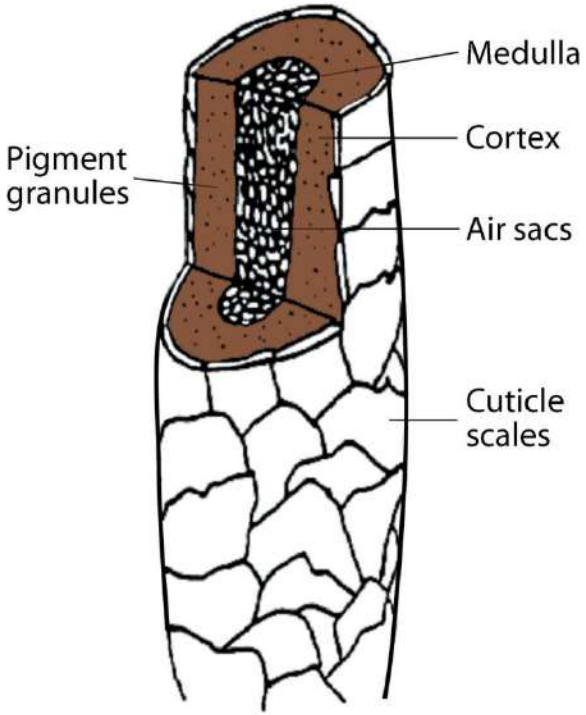
- Hair grows at the rate of 0.4mm/D (1 cm/m).

Structure of hair



Cross section of hair

- **Cuticle -** outside covering, made of overlapping, thin, non pigmented scales (5-10 scales thick). Its function to protect cortex.
- **Cortex -** middle layer consist of longitudinally arranged elongated cells without nuclei and fibrils are present within these cells and melanin lie over the fibrils
- **Medulla -** inner layer made of keratin and also contains air sacs called cortical fusi



Cuticle

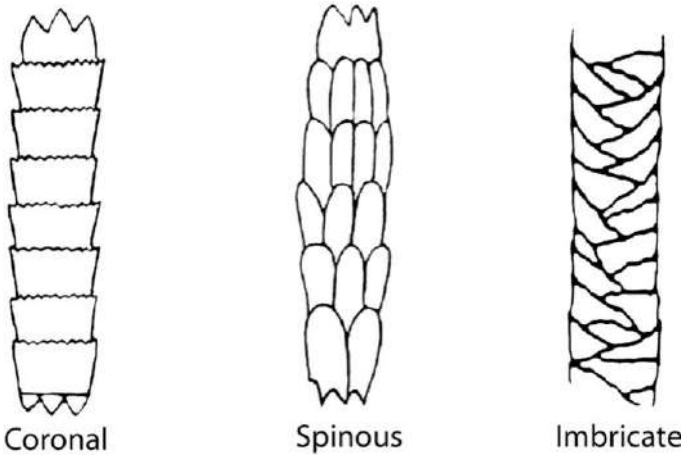
- The cuticle is the outermost layer of hair which is covered with scales. The scales point toward the tip of the hair. Scales differ among species of animals and are named based on their appearance.

- **The three basic patterns are:**

Coronal

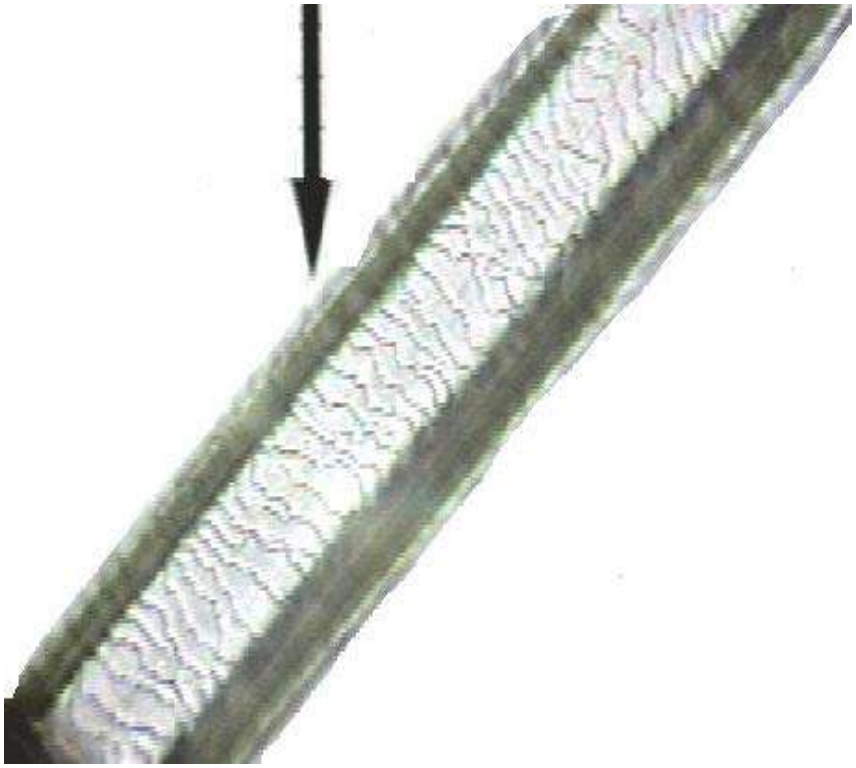
Spinous

Imbricate



Examination of cuticular scales

- Paint clear fingernail polish on a glass slide
- When the polish begins to dry, place a hair on the polish.
- When it is almost dry, lift off the hair and observe the scale imprints.



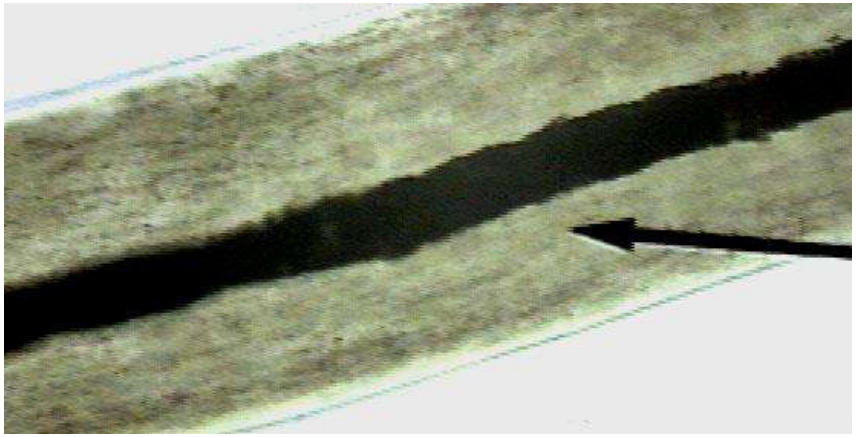
Medulla

- The medulla is the hair core that is not always visible. The medulla comes in different types and patterns.
- ***Types:***

  - Intermittent or interrupted
  - Fragmented
  - Continuous
  - Stacked
  - Absent—not present

Human Medulla

Human medulla may be continuous, fragmented, or absent.



Medullary Index

- Determined by measuring the diameter of the medulla and dividing it by the diameter of the hair.
- Medullary index for human hair is generally less than 1/3.
- For animal hair, it is usually greater than 1/2.

$$\text{Medullary Index} = \frac{\text{Diameter of medulla}}{\text{Diameter of whole hair}} \times 100$$

Human hair vs. Animal hair

- Fine and thin
- Cuticular scales are short, thin and irregular annular
- Cortex thick and 4-10 times as broad as medulla
- MI less than 0.3
- Pigments evenly distributed
- No banding seen
- Precipitin test for human

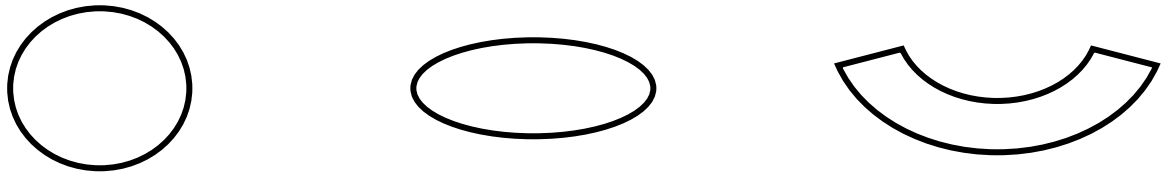
- Coarse and thick
- Cuticular scales are very large, have steps like or wavy projections
- Cortex thin and 2 times as broad as medulla
- MI more than 0.5
- Mostly concentrated towards medulla
- Banding may be seen
- Precipitin test for human concerned

Table 31: Human hair characteristics from Various body parts

S.No	Body part	Length	Shaft diameter	Tip	Medulla	Cross-section
1.	Scalp	1-100 cm	20-130 µ. Less variation along length	Tapered	Different types	Circular, elliptical or oval
2.	Eyebrows and eyelashes	<1 cm	Sharp change along length	Pointed	Broad	Circular
3.	Nostrils	<1 cm	Sharp change along length	Pointed	Variable	triangular
4.	Beard	5-30 cm	Broad	Blunt; sharply cut	Discontinuous	Triangular
5.	Axilla	1-5 cm	Broad	Round or frayed	Discontinuous	Circular
6.	Chest	>3 cm	Appreciable variation along length	Fine	Different types	Circular
7.	Arm and leg	<1 cm	Sharp change along length	Fine	Complex	Circular
8.	Pubis	1-5 cm	Curly, kinky, large variation along length	Round or frayed	Broad	Irregular

Hair Shape

- Can be straight, curly, or kinky, depending on the cross-section, which may be round, oval, or crescent-shaped.



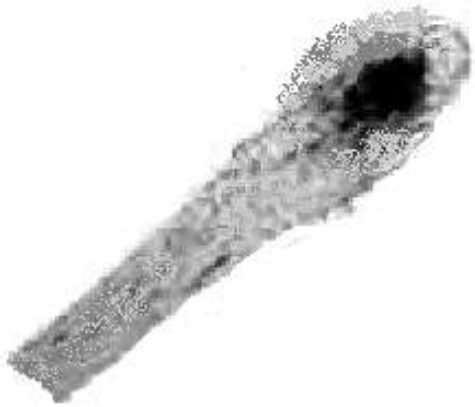
Round
(Straight)

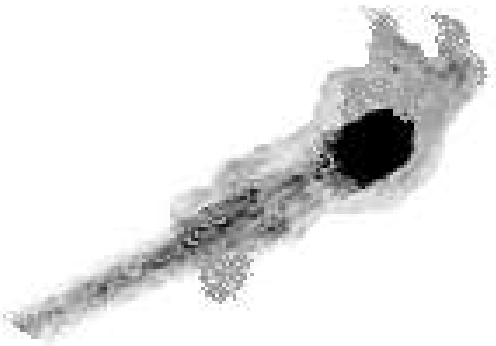
Oval
(Curly)

Crescent moon
(Kinky)

The Root

- Human roots look different based on whether they have been forcibly removed or they are telogen hairs and have fallen out. Animal roots vary, but in general have a spear shape
- Hair roots dissolved in KOH in children.





Sex

- Male hair – Coarser, darker, thicker
- Female hair – long, fine, silky
- If hair follicles present –

a. Barr body – female
b. Amelogenin – male or female

- Significant difference between sexes in hair diameter.

Age

- Scalp hair – with increasing age, graying and thinning, increased loss.
- Facial hair increasing in women at about menopause.
- Body hair – in fetus and newly born children show lanugo hair (fine, non medullated, non pigmented), non pigmented (colorless), soft, scale pattern simple
- In adults they are coarse, medullated, pigmented, tough, more complex scale pattern.
- Axillary and pubic hair are fine and soft but later become coarse, pigmented and curly
- Hair follicle decreasing with age
- Diameter measured by Atomic Force Microscopy.

DNA from Hair

- The hair shaft contains abundant mitochondrial DNA, inherited only from the mother. It can be typed by comparing relatives if no DNA from the body is available. This process is more difficult and more costly than using nuclear DNA.
- The root contains nuclear DNA. If the hair has been forcibly removed, some follicular tissue containing DNA may be attached.

color

- Dull grey – after burial
- Bluish – aniline worker, cobalt mineral, indigo
- Green – copper industry
- Light color – malnutrited children
- Orange – Henna used
- Yellow – picric acid
- Bleached hair – brittle, dry, straw yellow
- Dyed hair – color is not uniform, brittle, lusterless, rough

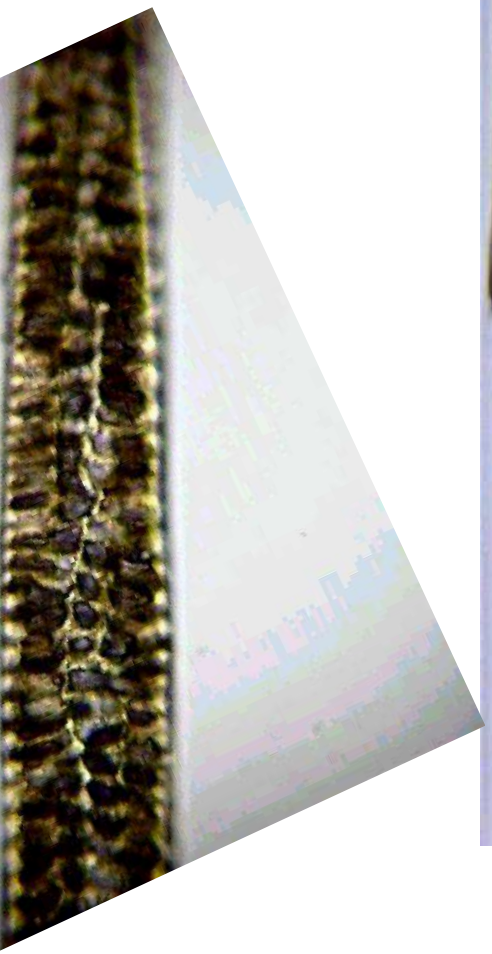
Comparison

- Color
- Length
- Scale pattern
- Artificial treatment
- Environmental damage
- Abnormalities
- Artifacts
- Trace element analysis by NAA
- Protein and enzyme in matrix and hair root sheath by electrophoresis and electrofocusing method.

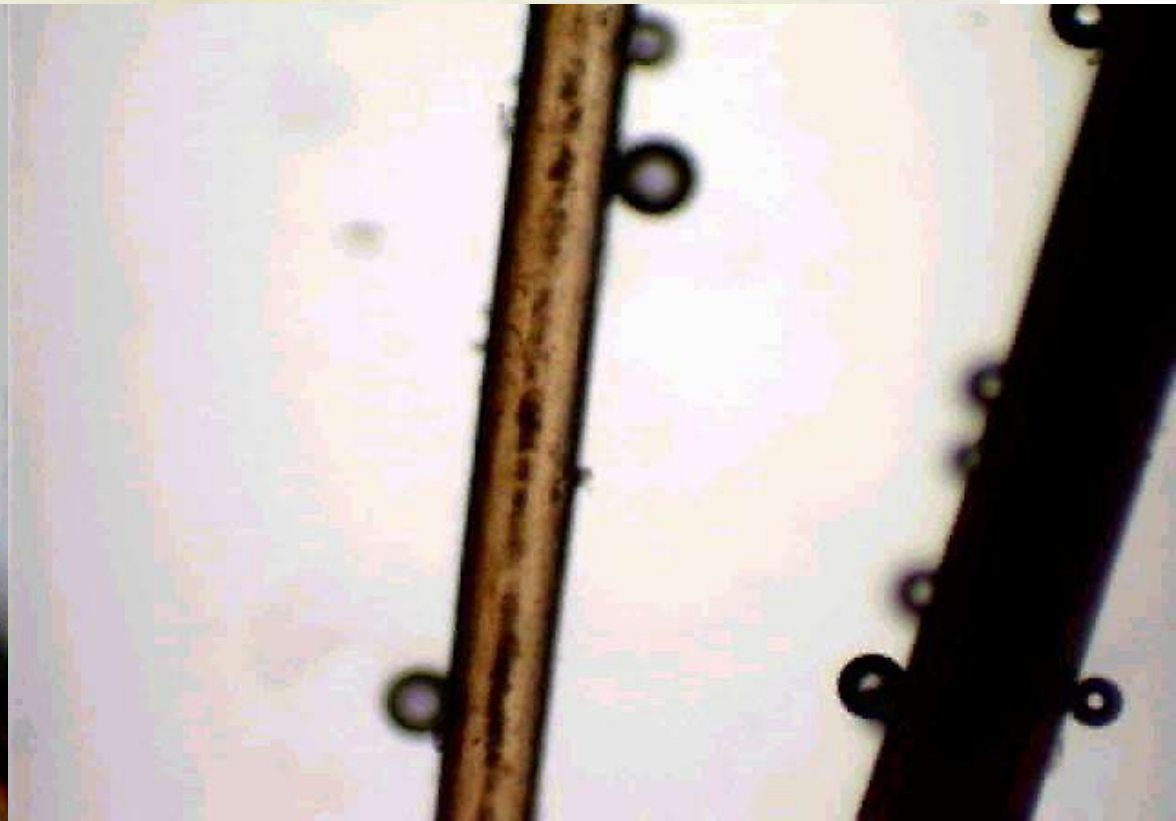
MLI of Hair

- Species
- Race
- Sex
- Age
- Injuries
- Trace evidence
- Toxicological analysis
- Rape cases
- Vehicular accidents

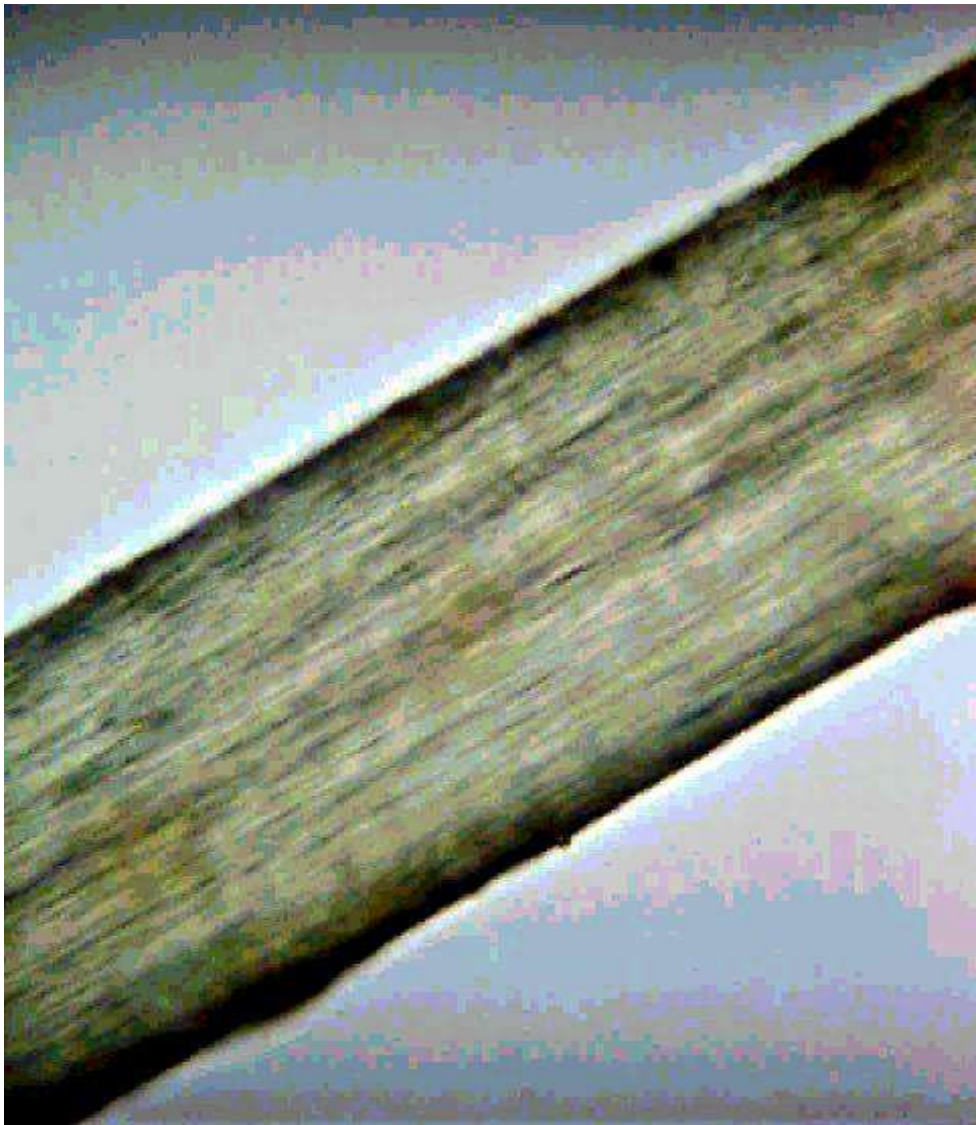
Medulla



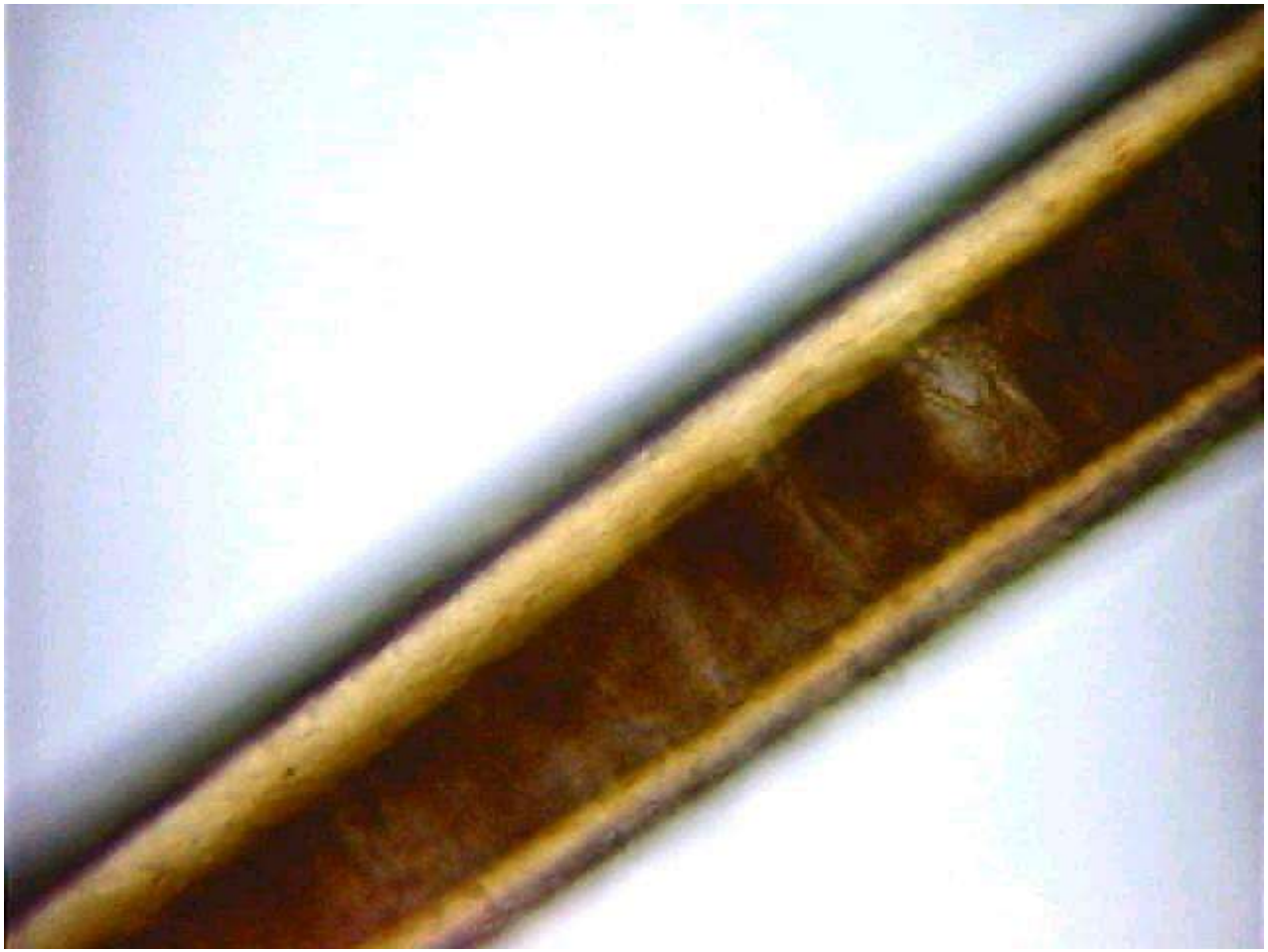
Human Hair



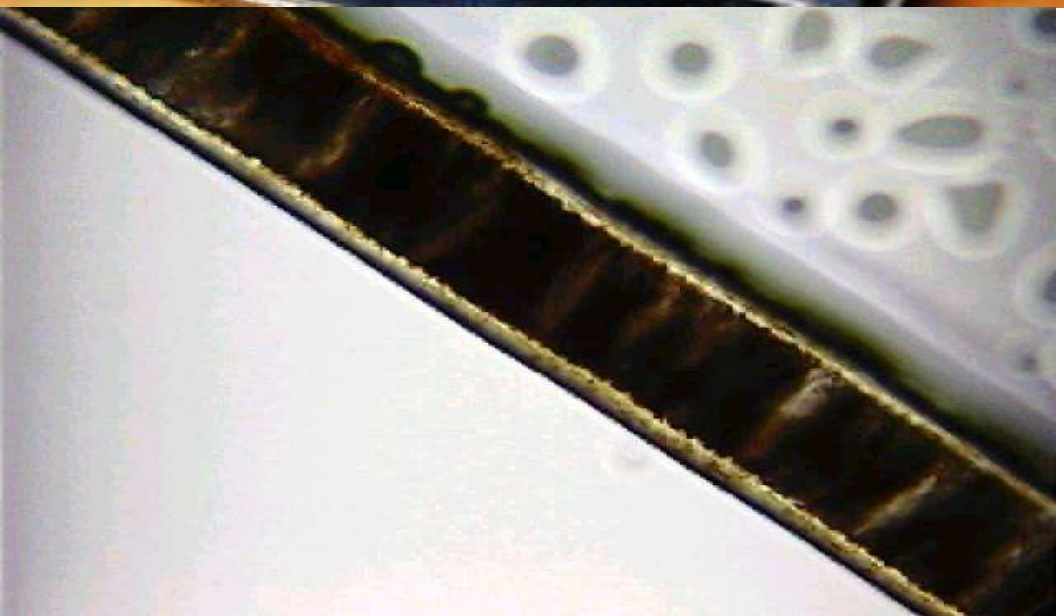
Horse Hair

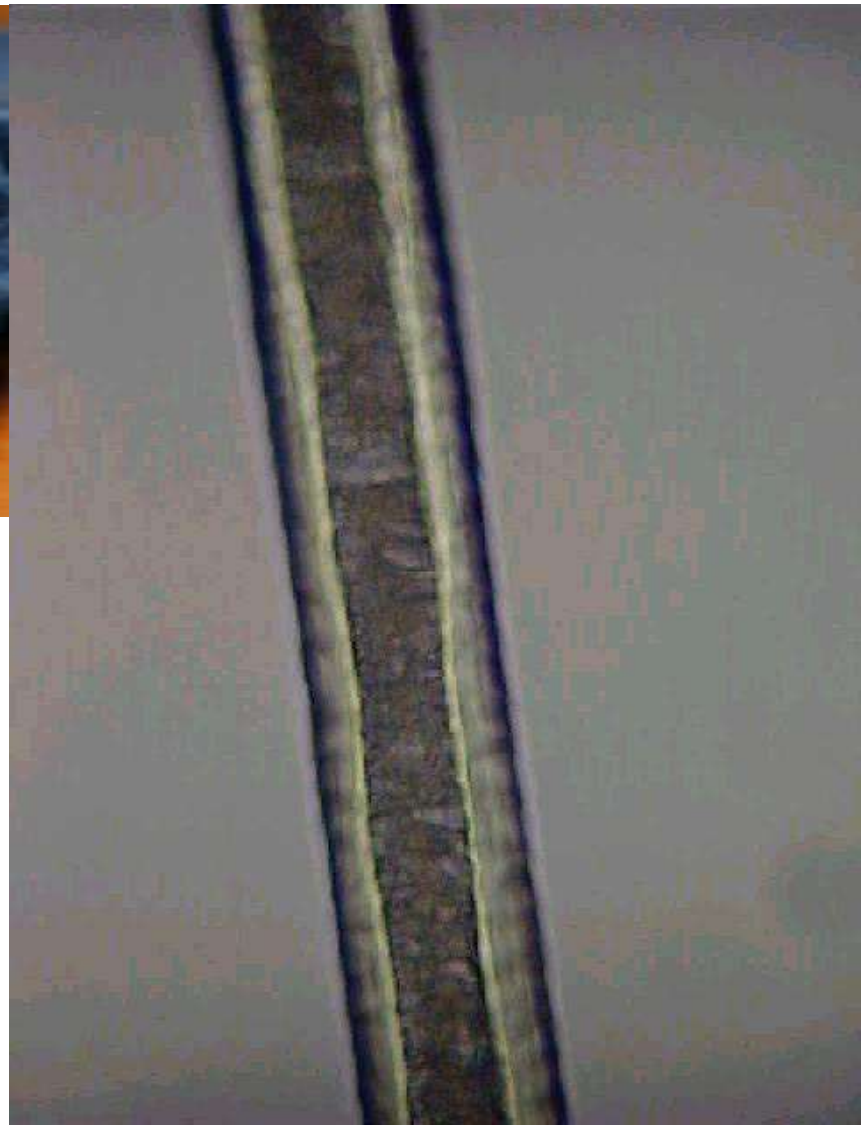


Dog Hair

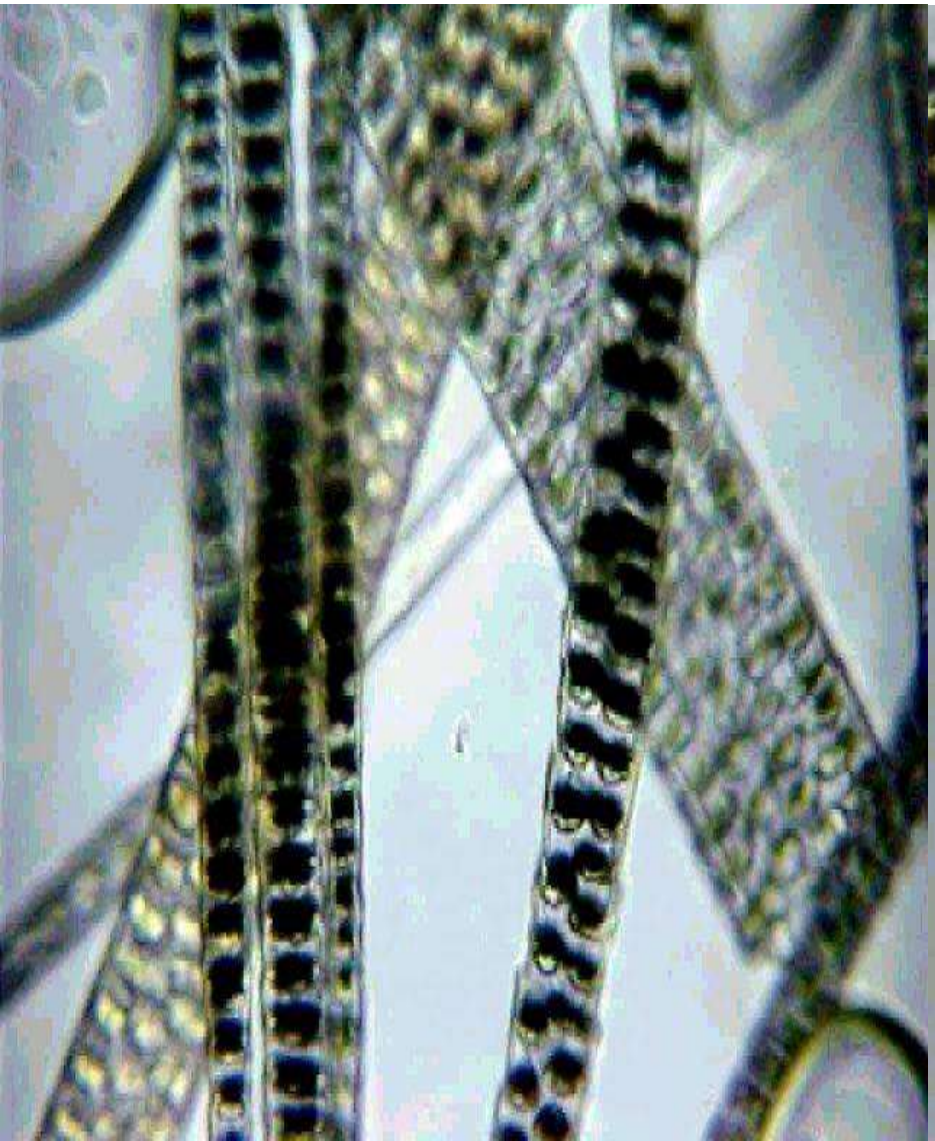


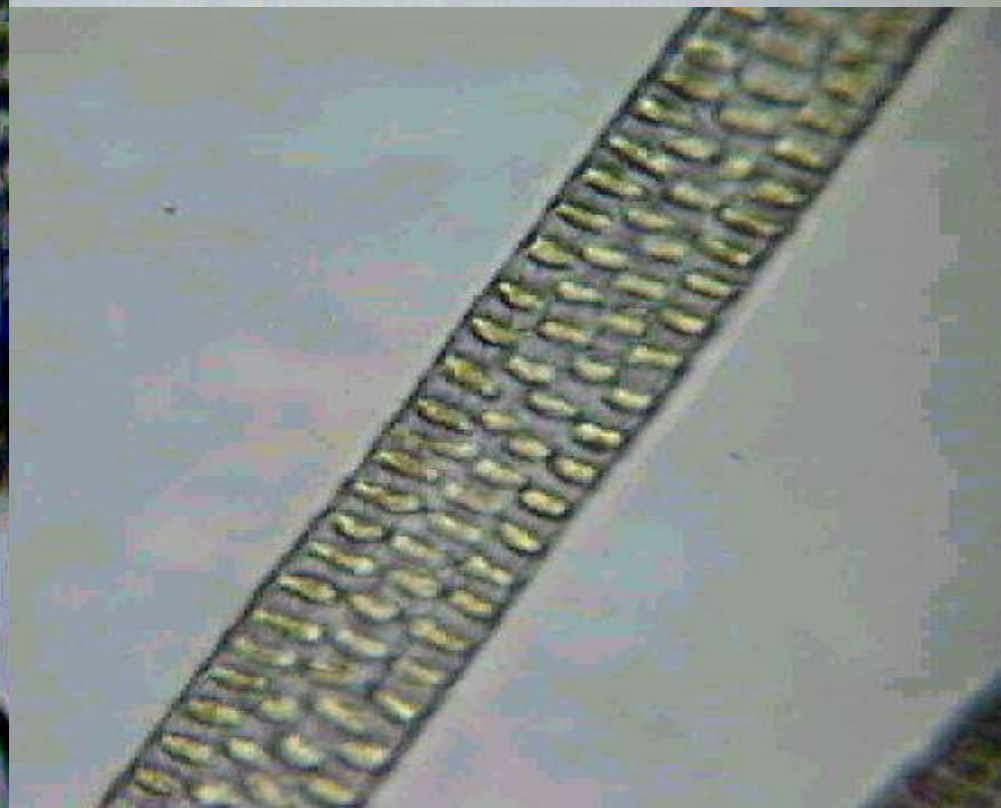
Cat Hair



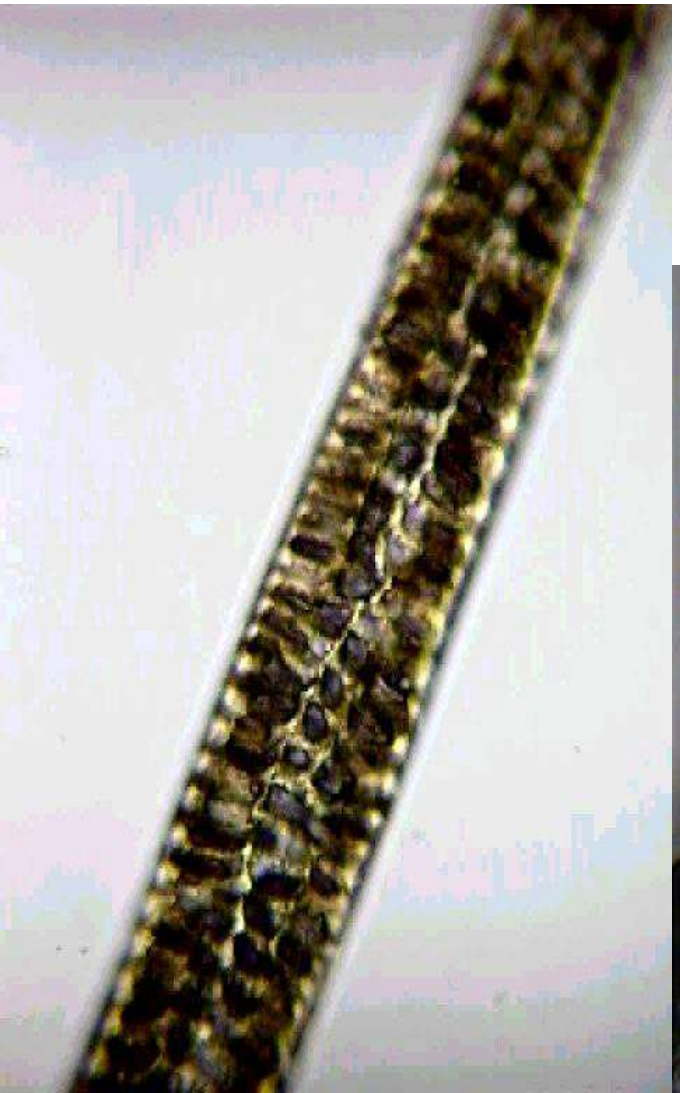


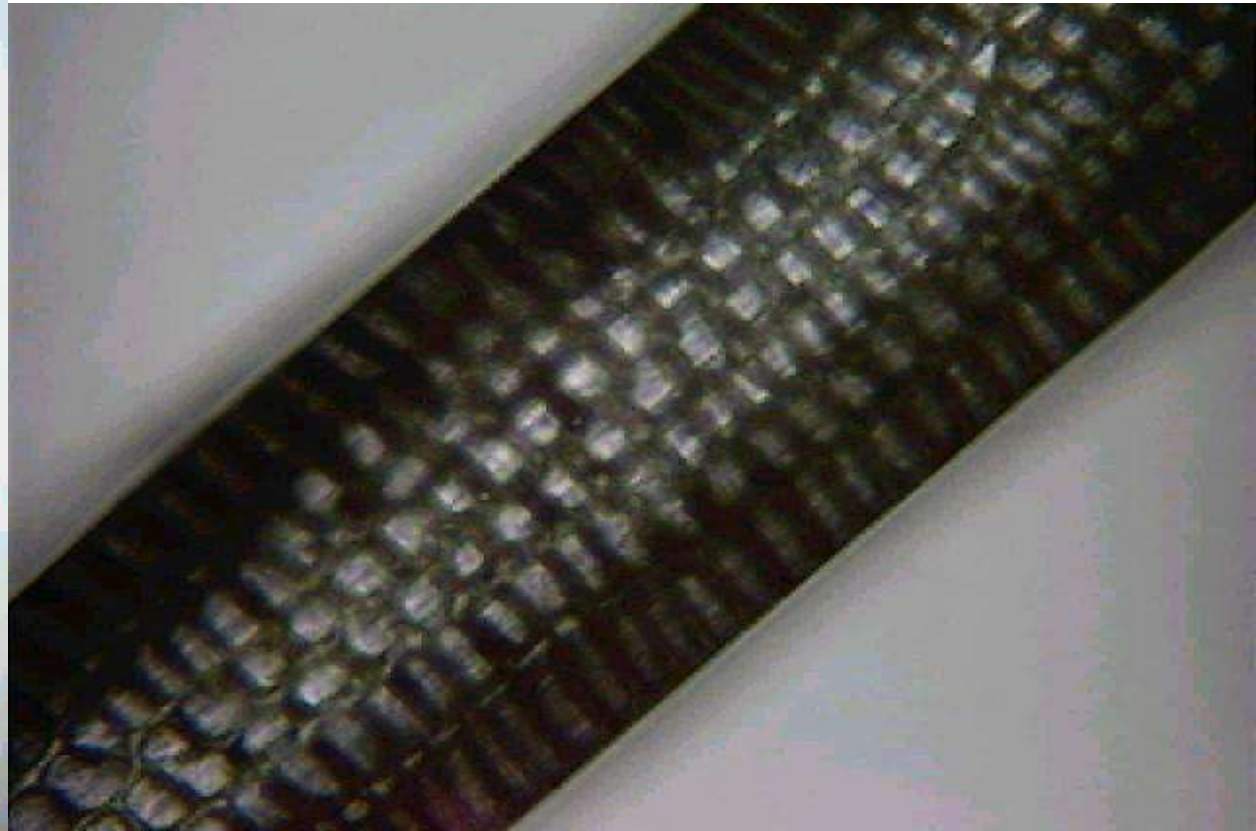
Mouse Hair





Rabbit Hair



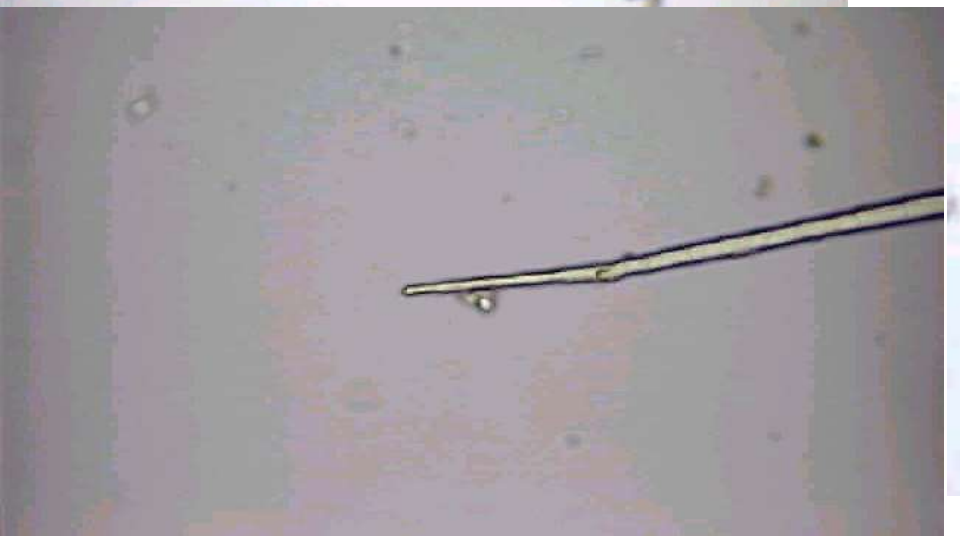


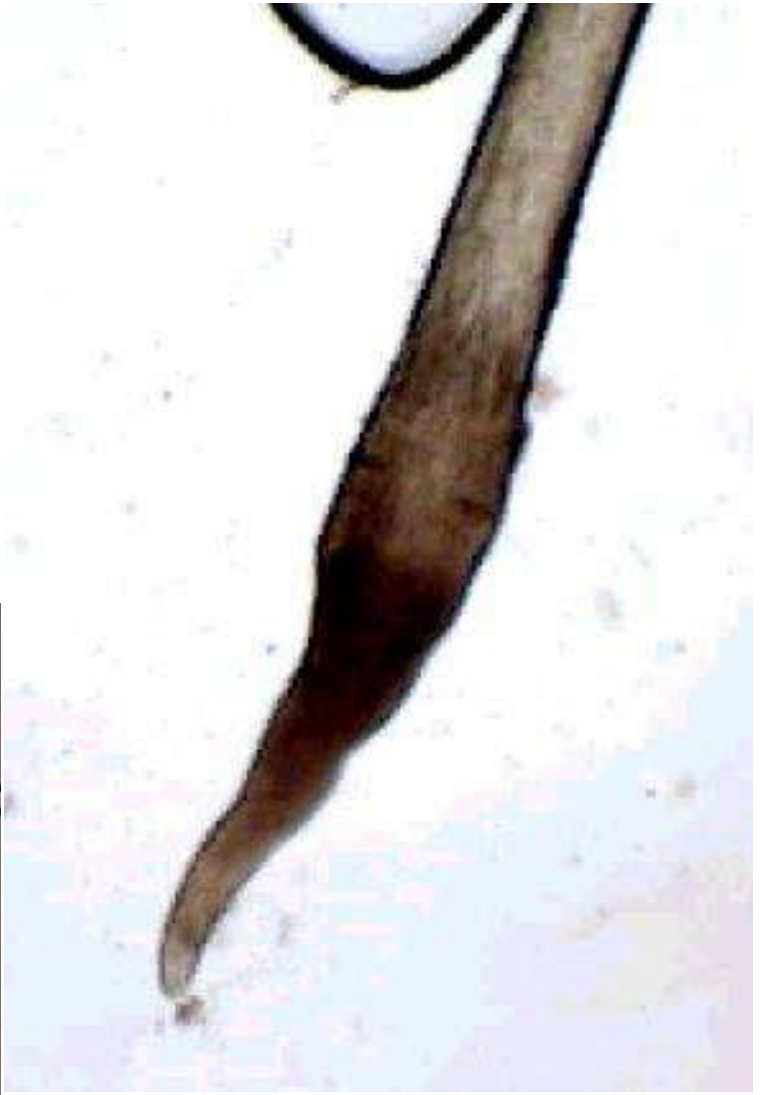
Deer Hair

Cow Hair

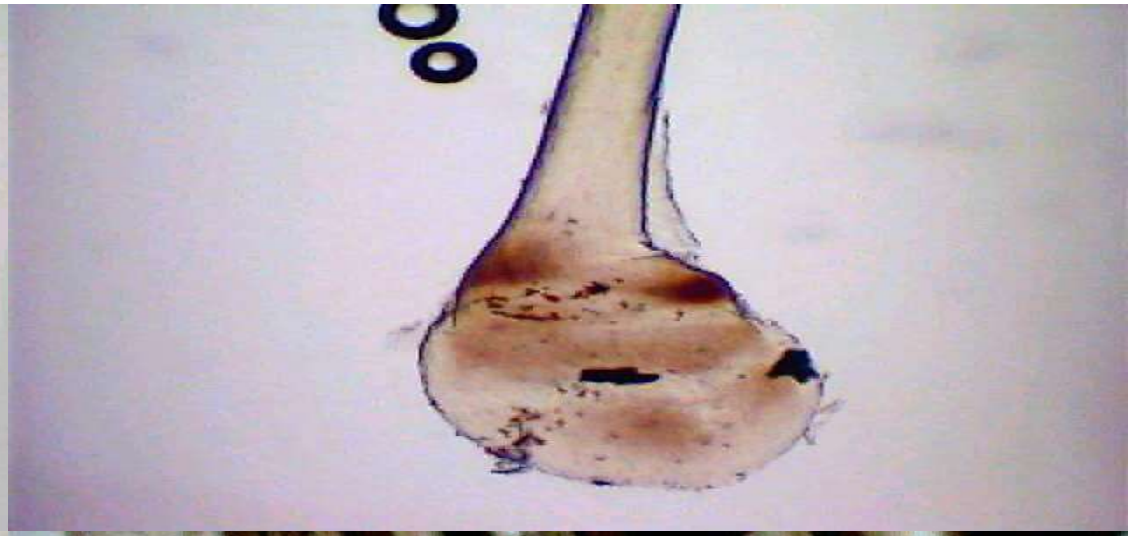
Pig Hair

Fallen out hairs

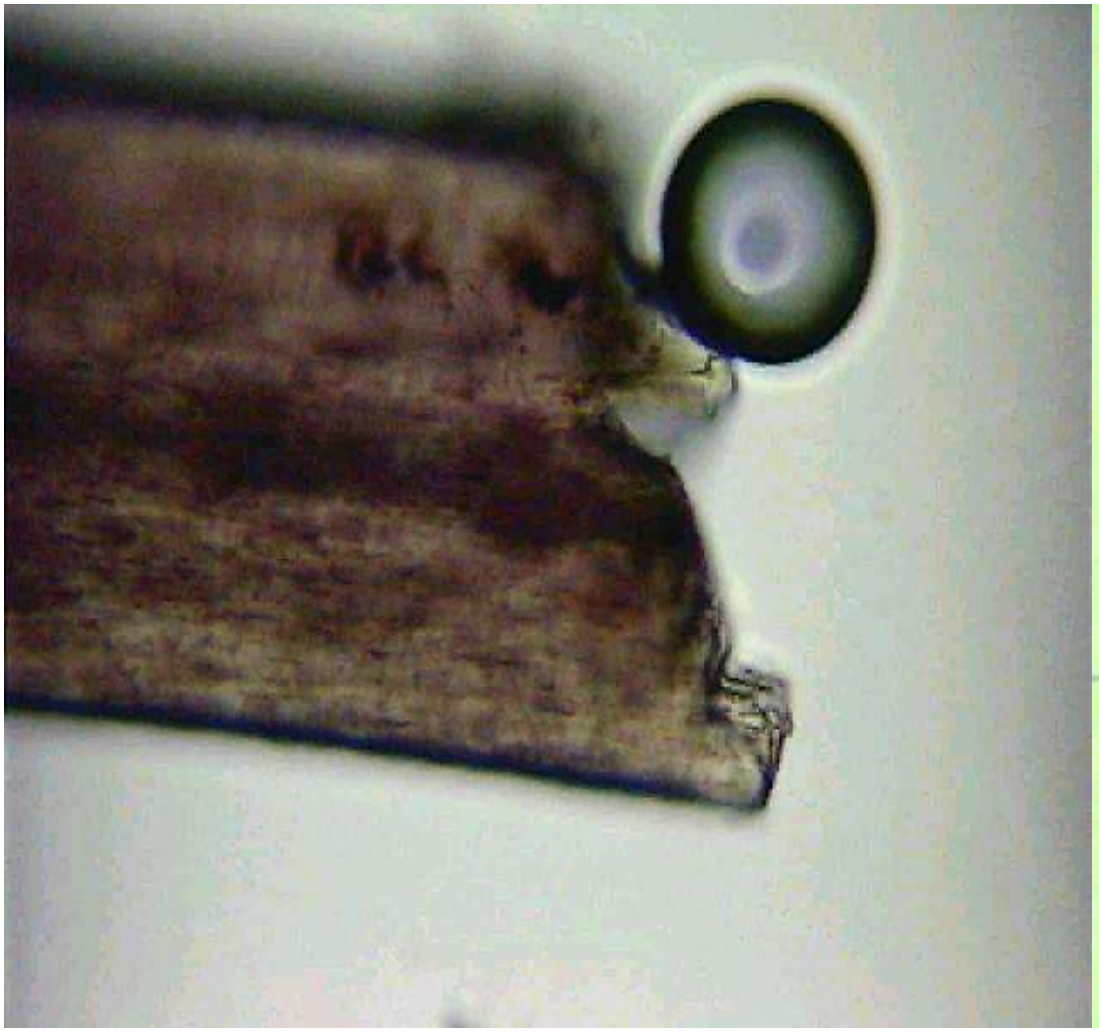


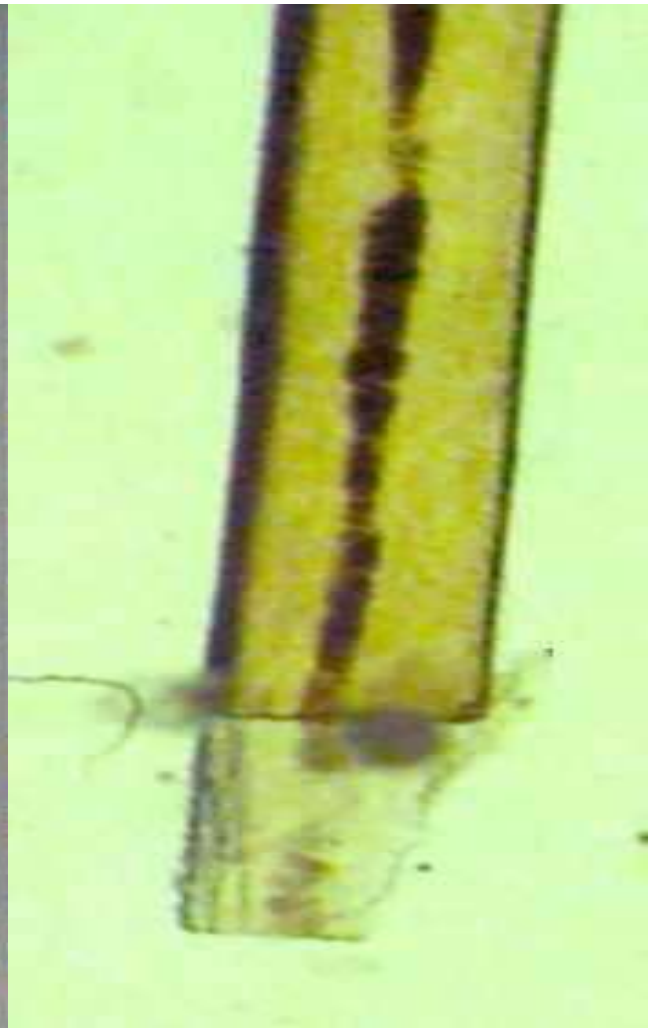


Pulled out by the root

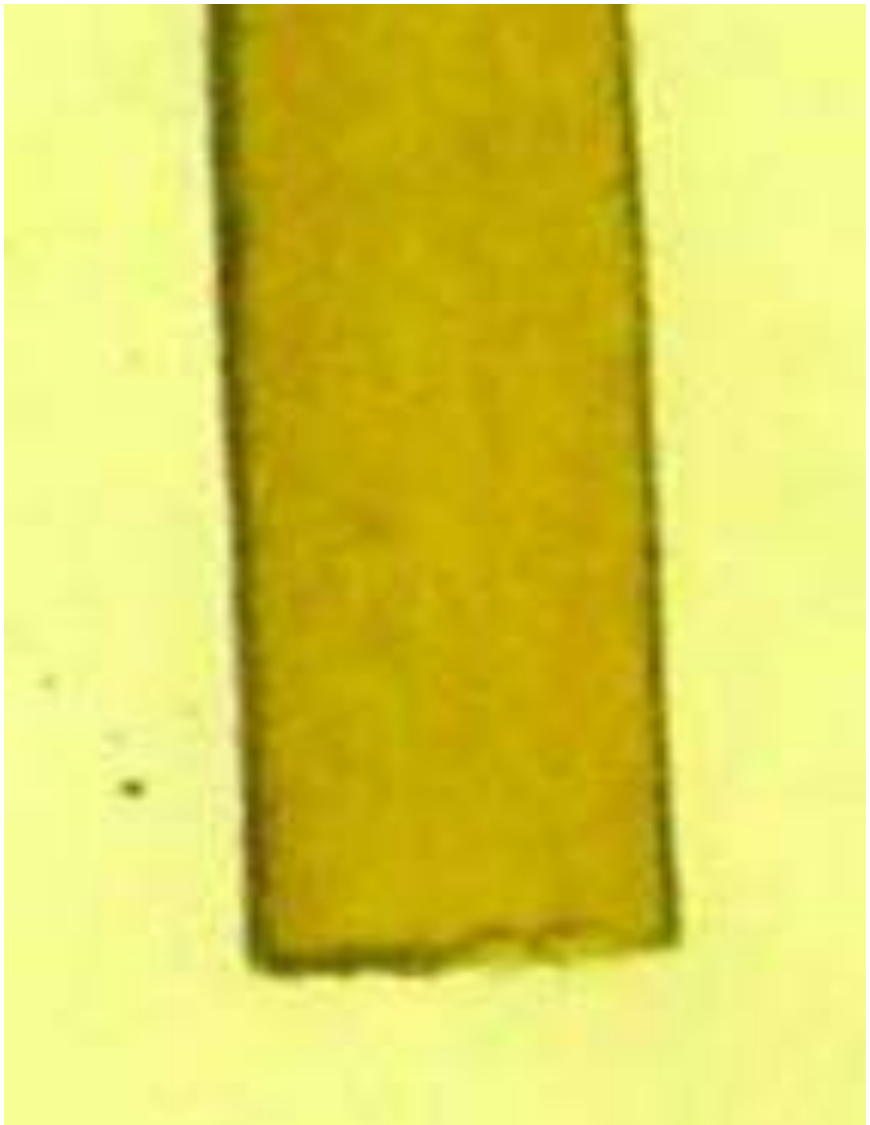


Broken/torn

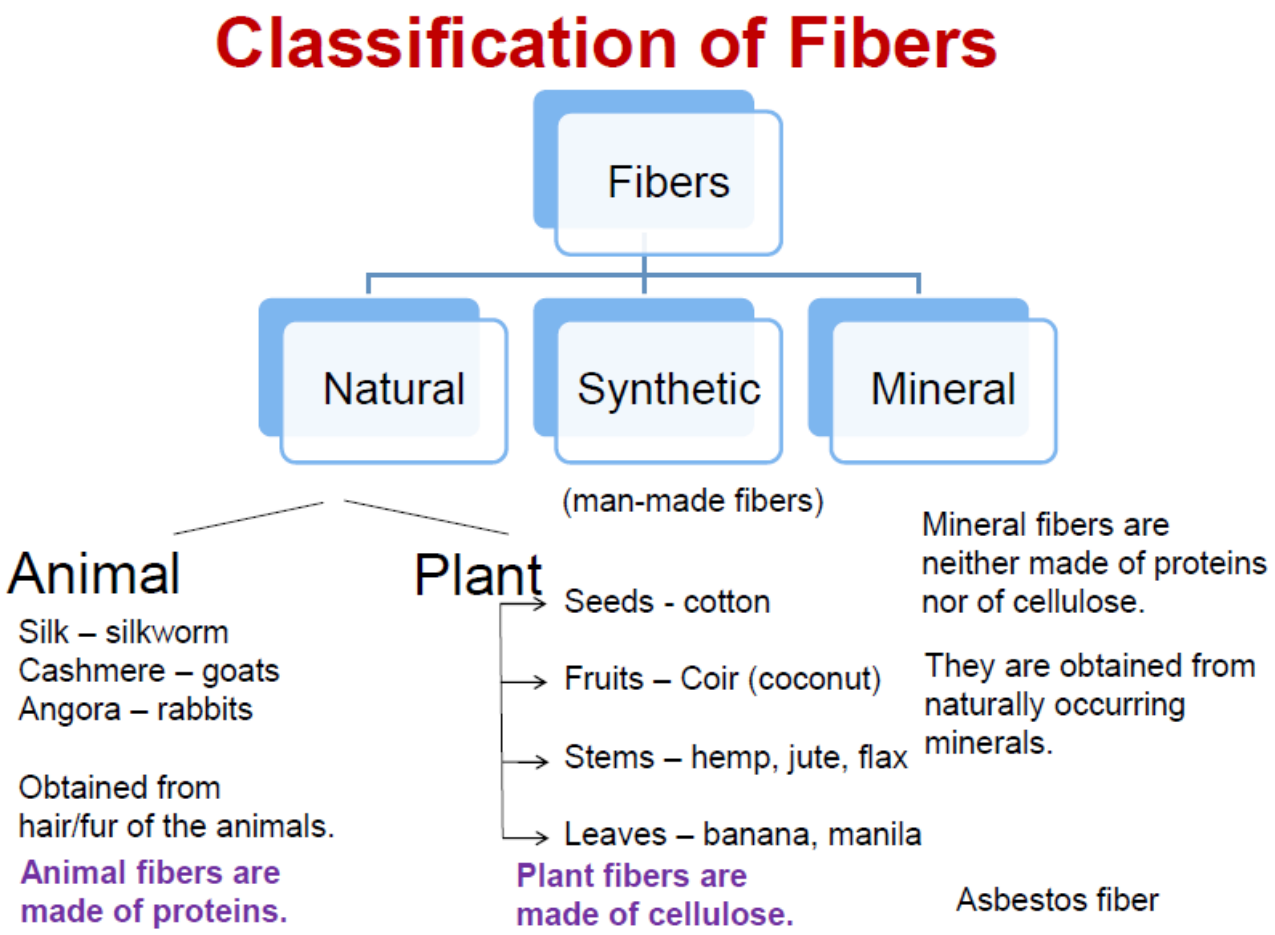




Cut Hairs



Fibers


Classification of Fibers
Fibers
Natural
Synthetic
Mineral
(man-made fibers)
Animal
Silk – silkworm
Cashmere – goats
Angora – rabbits
Obtained from hair/fur of the animals.
Animal fibers are made of proteins.
Plant
Seeds - cotton
Fruits – Coir (coconut)
Stems – hemp, jute, flax
Leaves – banana, manila
Plant fibers are made of cellulose.
Mineral fibers are neither made of proteins nor of cellulose.
They are obtained from naturally occurring minerals.
Asbestos fiber

- **Fibers are a trace evidence**.
- **Direct Transfer:** Transfer of fibers directly from victim to suspect or suspect to victim.
- **Eg:** fiber from woolen sweater of victim attacker
- **Secondary Transfer:** Fibers are transferred from the original source to a suspect and then to a victim.
- **Eg:** carpet fiber victim attacker

❑Coir

- Obtained from husk of coconut
- Very dense and stiff fiber
- Dark brown

❑Cotton

- obtained from cotton plants seed pod
- Insoluble in alkali and soluble in sulphuric acid
- Cross section is bean shaped, swelling almost round after absorbing moisture
- Each cotton fiber is composed of concentric layers
- Show double refraction when observed in polarised light

❑Jute

- Obtained from flax just like linen but the plants are processed slightly differently
- Jute fibers are smooth without transverse lines
- The cell cavity is not uniform
- The ends are blunt

❑Linen

- Obtained from the flax, a bast fiber taken from the stalk of the plants
- Narrow lumen
- Fibers show cross lines or folds about which the fiber is often swollen

❑Silk

- Obtained from the cocoon of silk warm
- Show crossover marks and a triangular cross section with rounded corners
- Consist of long clear threads without any cells
- Smooth and finely striated

❑Wool

- Obtained from animal coats: sheep, goats, rabbits etc
- Show an outer layer of flattened cell with overlapping margins
- Interior is composed of fibrous tissues

Synthetic fibers

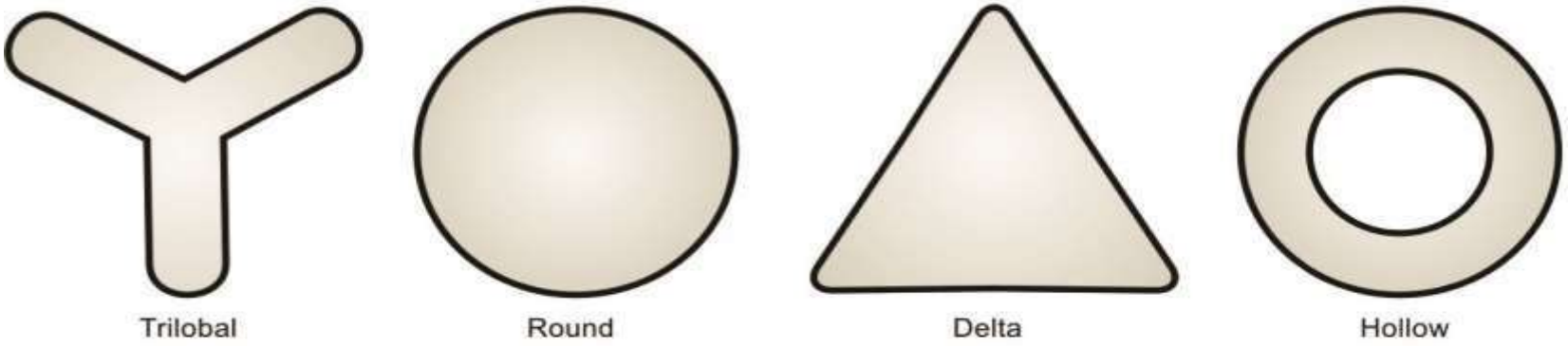
- Synthetic fibers include acetate, acrylic, aramid, nylon, polyesters and rayon
- They can be differentiated by noting their solubility in different solvents like HCl, HNO3, acetone and dimethyl sulfoxide
- Physical characteristics like density RI, melting/softening point
- Infrared spectroscopy

Fiber Analysis

- Characteristic features of fiber forensic analysis:
- Size
- Cross Section
- Color
- Crimp

Analysis of Fibers

- Observation of Fiber Cross Section-Microscopy
- Type of cross section helps identify the fiber.



- **Trilobal cross-section: more volume, sheen and better resilience.**
- **True delta cross-section: extra brightness and shine.**
- **Round cross-section: smooth silky luster.**
- **Hollow cross-section: light weight and improved insulation.**

Diameter

- Round fibers: one diameter
- Many fibers are not round!
- Oval and elongated fibers have more than one diameter!
- Both the diameters are recorded!

Delusterants

- Finely ground materials added to the chemical mixture from which the fiber is made.
- Act to reduce the fiber's shine, by scattering light.
- Eg: Titanium dioxide
- Delusterants of different shapes and sizes added to the pre-fabrix mix.
- Observation of these delusterants in the unknown evidence and known evidence.

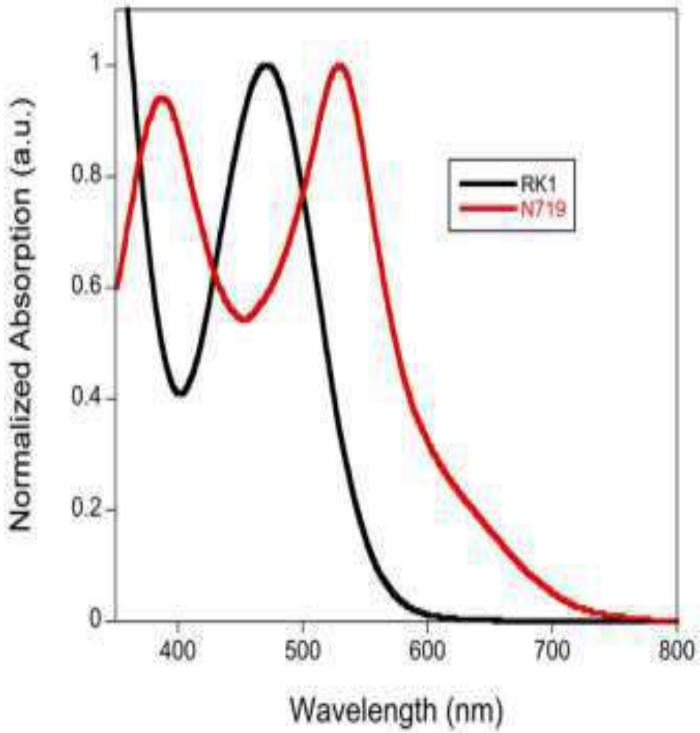
Refractive Index

- Submersion Method.
- The shape of the fiber may cause it to have more than one refractive index.
- Reason: light travels at different speeds in the fiber depending on whether it travels through the length and diameter of the fiber.

Color

- Naked eye observation: subjective!
- Metamerism

  Visible Spectrophotometer.
- Dyes: even, uniform coloration
- Pigments: Uneven coloration



Fourier Transform Infrared Spectroscopy (FT-IR)

- non-destructive fiber analysis
- Identifies the chemical composition of fibers.
- Not just the class, but also the sub-class to which the fibers belong!
- Nylon 6-6 and Nylon 6-12.

Pyrolysis Gas Chromatography

- Requirement: Just about 1/8th of a fiber.
- Destructive analysis mode.
- Better than FT-IR in distinguishing closely related fibers.

Scars

- A scar is fibrous tissue covered by epithelium devoid by hair follicles, elastic tissue, sebaceous and sweat gland and pigments
- They are usually produced after the healing of a wound involving dermis
- If the wound involving only epidermis, it will regenerate without the formation of a scar
- Scar once produced are permanent, that is why they serve as good identification marks

Characteristics

- All scars are usually depressed, raised in negros due to keloid formation
- Incised wound – linear scar
- Lacerated wound – prominent, irregular, firm scar
- Bullet wound – depressed scar
- Scars from scalds and corrosive acids – splashing marks as well as sign of dribbling
- Stab wound – depends upon the cross section of knife
- Vaccination scar – circular, oval, flat or slightly depressed

- Scars may be accidental, due to disease or surgical.
- If produced in childhood, grows in size as child grows
- Scars can be visualized by naked eye or magnifying glass
- If scar is faint, can be visualized by the application of heat, UV light or surface friction
- Scar can be erased by skin grafting or excision

Tattoos

- Tattoo marks are designs made by multiple small puncture wounds made through the skin (dermis) with needles or similar penetrating tools in dipped in coloring agents
- They are special marks, designs, pictorial diagrams or alphabetical messages, names of self, husband, lover made or written permanently on the skin of body
- Common sites are front of forearm, upper and lower limb, back of neck, abdomen, hip, breast, vulva, penis, buttocks
- Record exact size, shape, design, color, site
- Photography best way to record

Dyes

- Henna and Mehndi
- Salts of heavy metals – Al (green, violet), Ba (white), Cd (red, orange, yellow), Cr (green), Co (blue), Cu (blue, green)
- Metal oxides
- Organic chemicals – azo dyes, naptha dyes
- Homemade or traditional inks
- Glow in the dark tattoo inks
- UV reactive tattoo ink

Tattoo removal

- Surgical removal – excision and skin grafting
- LASER
- Corrosives
- Cover-up
- Miscellaneous – Carbon dioxide snow, disease, elecrolysis

❑**Medical tattoos**






Exhumation

- Exhumation is authorized digging out the dead body from grave, in order to establish his cause of death or other relevant facts
- Exhumation for first autopsy
- Exhumation for second or third autopsy
- For grave identification
- No time limit

Reason for exhumation

- Criminal
  - Determination of cause of death
  - Retrieving evidence
- Civil
  - Identification
  - Other
- Historical reason

- Exhumation can be done only on the written order of executive or judicial magistrate
- Procedure
  - Information to relatives
  - In the presence of magistrate, MO, police
  - Identification of grave
  - Early morning
  - Removal of earth
  - Measurement
  - Photography
  - Recovery of body
  - Identification of body

Sources and suggested reading:

- Textbook of Forensic Medicine and Toxicology, Anil Aggrawal, APC publication
- Review of Forensic Medicine and Toxicology, Gautam Biswas, JAYPEE publication
- The Essentials of Forensic Medicine and Toxicology, Dr. K S Narayan Reddy and Dr. O P Murthy, The Health Science Publisher
- Textbook of Forensic Medicine and Toxicology, P C Dikshit, PEEPEE publications
- Research papers


Thank
you!