

Hair Analysis in Forensic Science

General introduction of Hair

- **Definition:** -

A hair can be defined as a slender, thread-like out growth from a follicle in the skin of mammals.

There are **three types of hair usually seen in animals:** -

1. **Vibrissa:** - These are the whiskers of many animals. They are normally tactile and sensitive, such as the whiskers on a cat.
2. **Bristle:** - This is the coarse bristle that provides an animal with a protective coat. These guard hairs can readily be identified by their distinctive appearance and morphology between various animal families.
3. **Wool:** - Wool or fur provides insulation from wet and cold. These fine hairs cover the bodies of all mammals.

- **Four types of hair appear on the bodies of humans:** -

Primordial hairs appear as early as the 3rd month of gestation, growing on the upper lip, the eyebrows, the palms and soles of the fetus. They gradually disappear and are replaced by softer lanugo hair over the entire body.

Lanugo hairs are normally shed after the 6th month of gestation. They are fine, soft, unmedullated, and normally unpigmented hairs. The surface of lanugo hair is smooth.

Vellus hairs are the fine, soft, unmedullated hairs spread uniformly over the body surface. They rarely are more than 2 cm in length.

Terminal hair is found on the scalp, eyebrows, eyelashes, and, to a lesser extent, the limbs of both sexes. Puberty is accompanied by pubic and axillary hair growth such as hair of the face, chest, back, arms, and legs. The various terminal hair types can be distinguished by density and morphology.

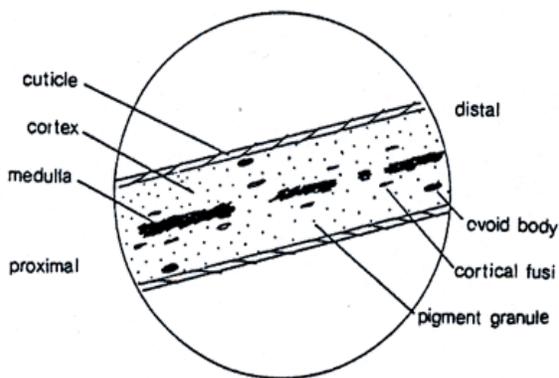


Figure of Hair

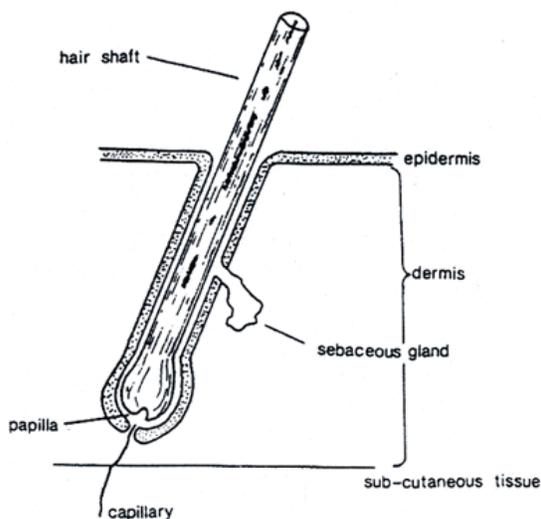


Figure of hair in skin

- **Outer structure of hair: -**

- 1) Root
- 2) Shaft
- 3) Tip

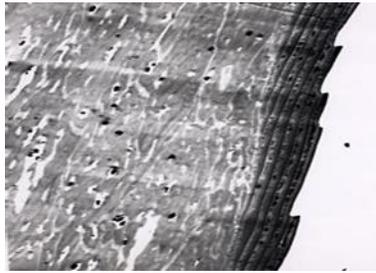
- **Inner structure of hair: -**

- 1) Cuticle
- 2) Cortex
- 3) Medulla

- **Cuticle: -**

The cuticle is a translucent outer layer of the hair shaft consisting of scales that cover the shaft.

Scales always point from the proximal or root end of the hair to the distal or tip end of the hair.



Scanning Electron Photomicrograph of Hair

3 basic patterns of cuticle: -

- **Coronal (crown-like) -** Unusual in humans; common in rodents and bats.

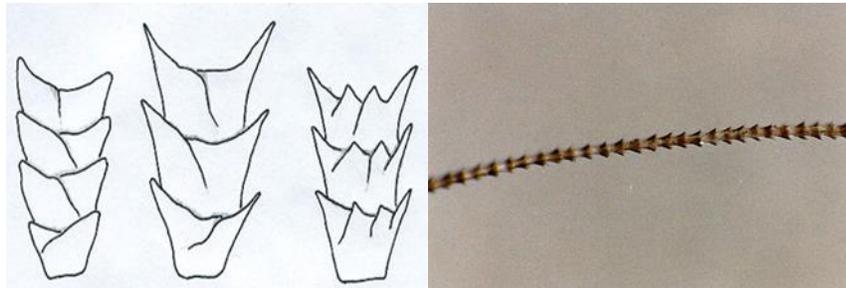


Figure of Coronal Scales

Photomicrograph of Bat Hair

- **Spinous (petal-like) -** scales triangle; not in humans but typical of cats.

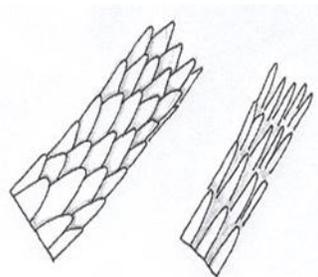
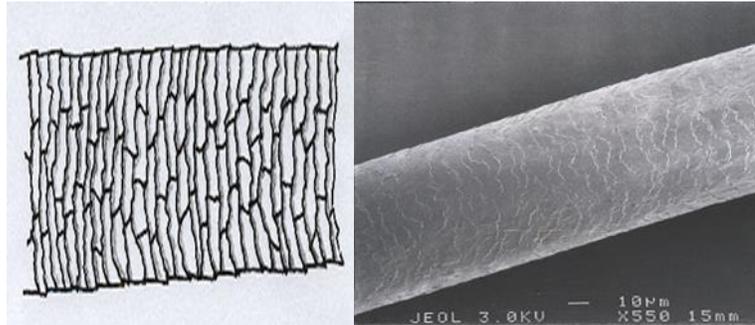


Diagram of Spinous Scales

- **Imbricate (flattened)** – Found in humans and many other animals.



Photomicrograph of Scale Pattern (Human)

- **Cortex**

The cortex is the main body of the hair composed of elongated and fusiform (spindle-shaped) cells.

The cortex gives the hair its shape.

Largest portion of the shaft.

It has 2 major characteristics: -

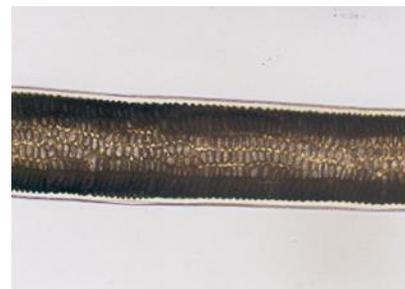
1. **Melanin:** – pigment granules that give hair its color.
2. **Cortical fusi:** – air spaces, usually found near the root but may be found throughout the hair shaft.



Photomicrograph of Pigment Distribution in Human Hair

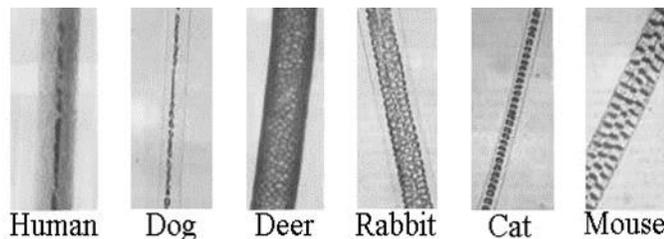
Medulla

The medulla is the hair core or central canal that is not always visible.



Photomicrograph of Uni serial Ladder Medulla Malty serial ladder medulla

MEDULLA OF DIFFERENT ANIMALS: -



• Biochemistry of hair

Chemically hairs are made up of proteins, mostly keratin. It consists of: -

- 1) Protein \approx 65-95%
 - 2) Water \approx 32 %
 - 3) Lipids \approx 1-9 %
 - 4) Pigment and trace elements $<$ 1%
- Strong disulfide bonds linking adjacent keratin chains produces a structure that is extremely resistant to chemical and biological degradation.
 - Melanin pigment is a long structure and made of monomer of indole and Quinone.
 - Tyrosinase enzyme is responsible to give colored structure to the melanin.
 - Cuticle and shaft cells are made up of glycogen.
 - Medullary canal is made up of protein structure (glycine).
 - Zn and Cu are also found in hair.
 - For the formation of melanin and color of the hair high activity of the enzyme tyrosinase is necessary and hair starts greying when its activity is reduced.
 - The cortex cells and the cuticle cells are called matrix protein, which generally contains high amount of sulphur and amino acids (glycine and tyrosine).

• Hair growth

- 1) **Anagen** - hair that is actively growing; lasting up to 5 years.
- 2) **Catagen** - hair is not growing; a resting phase.
- 3) **Telogen** - hair that is dying and ready to fall out; lasting two to six months. Grows about 0.5mm per day or 1cm per month; approximately one-half inch per month. Hair is replaced every 3-5 years.



Anagen

Catagen

Telogen

- **Hair examination**

Examination of hair can help in the determination of species or origin, sex, site (part of body), genetic markers and source by comparison.

Different morphological and histological characteristics of hair can be examined under microscope/ stereomicroscope by temporary or permanent mount, scale casting, cross-sectioning and micrometric analysis.

- **Temporary mount: -**

Make a temporary mount of the hair sample on a clean slide with the distilled water or glycerin. Cover with cover slip.

Examine under microscope from one end of hair to other for general appearance, length, color, treatment -dye or bleached, presence or absence of root, tip and shaft characteristic and contamination, if any.

- **Scale casting: -**

- ✓ **Nail polish / Cellulose acetate method: -**

Each hair sample should be cleaned before examination with suitable detergent to remove dust and debris and blot dried.

On the clean microscope slide, place a thin layer of Nail polish (cutex) / Cellulose acetate paste with low viscosity.

With fine forceps, place hair onto the Nail polish (cutex) or Cellulose acetate paste and press with another clean slide.

Allow it to dry for 2-5 minutes.

With fine forceps, lift the hair from root end and gently peel the hair from the slide and observe the scale impressions left on the cast microscopically.

- ✓ **Polaroid coater method: -**

Place the hair on a clean microscope slide, securing the ends with cellophane tape.

Using a polaroid film coater, make 2-3 passes along the length of the hair, wetting the slide and hair thoroughly.

Allow it to dry for 2-5 minutes.

After removing the cellophane tape, gently peel the hair from the slide.

With a sharp scalpel, slice away the excess coating protruding above the flat surface of the scale cast.

Observe the scale impressions microscopically.

- **Permanent mount: -**

Place hair on slide in a drop of xylene and add permanent mounting medium.

Place a cover slip on the hair allowing the medium to spread under cover slip encasing hair.

Label the slide allow it to dry for 48 hours.

Examined for different morphological characteristics and micrometry.

- **Standard and controls**

Animal hairs: -

Sufficient samples of hairs from different species should be maintained in a laboratory for reference and comparison purpose.

Human hairs: -

Hairs of unknown origin may be compared with hairs of known origin to determine the possibility of a common source.

Difference between Human & Animal Hair

Feature	Human Hair	Animal Hair
Cortex	The width of cortex greater than medulla	Usually less than of medulla
Distribution of Pigment	Towards cuticle	Central or denser towards medulla
Medulla	Medulla dis-continuous	Medulla continuous
Scales	Imbricate	Coronal, ring form