

Hair Analysis

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Hair can be important physical evidence at a crime scene. Hair normally falls from the body over the course of a day. It will stick to a number of materials, especially fabric and clothing. Hair is not easily destroyed, even with exposure to moisture and decomposition of accompanying tissue.

There are three types of hair usually seen in animals:

Vibrissa. These are the whiskers of many animals. They are normally tactile and sensitive, such as the whiskers on a cat.

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.

Wool. Wool or fur provides insulation from wet and cold. These fine hairs cover the bodies of all mammals.

Head and body hair of humans is classified as intermediate hair combining the characteristics of bristle and wool hairs. 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 with almost indiscriminate scales. It is replaced by vellus and terminal hairs. Lanugo hair is often observed on an aborted fetus and can be useful in investigation of possible infanticide.

Vellus hairs are the fine, soft, unmedullated hairs spread uniformly over the 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.

Hair is an appendage of the skin that grows out of an organ known as the hair follicle. (See figure H-1) The root is the portion that lies in the follicle, and the portion above the skin surface is the shaft. The base of the root is called the bulb. Hair is composed of a group of proteins (keratins) that interconnect to form stable fibrils. Keratin protein chains are very complex both histologically and chemically due to the multiplicity of the cross-linked protein molecules. One of the more important linkages between adjacent keratin chains is the disulfide bond (-S-S-) that makes the keratin extremely resistant to biological and chemical degradation. It is through breaking and reforming of the disulfide bonds that hair can be reshaped through a permanent. Also, toxins, expelled from the body, can be found in the hair.

A hair shaft consists of a translucent outer layer called the cuticle. It consists of overlapping, nonnucleated, pigment-free cells that form scales. (See Figure H-2 and Figure H-3). These scales are composed of specialized cells that have hardened (keratinized). The free ends of the scales point away from the root toward the distal end of the hair shaft.

The cuticle structure is different for each type of hair from different animals.

The distal margins for human hair normally do not protrude, leaving the outer margin flat. Animal hair, such as cat or rabbit, are highly serrated and interlocking.

Hair cuticle can be damaged leaving cracked, ragged, or flattened outer or inner cuticular margins. (See Figure H-4)

The cortex is composed of elongated, fusiform, keratinized filaments aligned parallel to the length of the hair. Variable amounts of air spaces called cortical fusi are interspersed among the cortex. Initially, the fusi are filled with fluid, but later become filled with air as the hair dries out.

Hair color, although influenced by cortical fusi, the medulla, and cuticular surface is primarily due to the amount of pigment in the cortex. The coloring is due to pigment granules (melanin) interspersed throughout the cortex. Microscopically, hairs show only black, brown, and yellow pigment granules. True blond and red hair color pigments are called pheomelanin. The size and shape of the pigment granules, as well as their density and distribution along the shaft, will differ from individual to individual.

Hairs exhibit a cellular column running through the center of the cortex called the medulla. (See Figure H-5) The presence of this feature varies from individual to individual and between hairs of a given individual. In humans, the medulla appears dark under transmitted light because it is filled with air. If filled with fluid, the medulla may take on a yellowish color. If not visible under normal microscopic examination, the medulla may be more easily observed between crossed polar of a polarizing microscope.

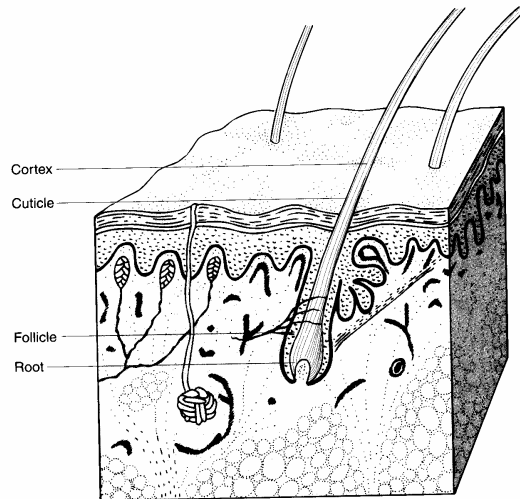


Figure H-1: Cross section of the skin showing hair follicles. Reference: Reproduced from Saferstein, **Criminalistics**, 5th Ed., Prentice Hall, 1995.

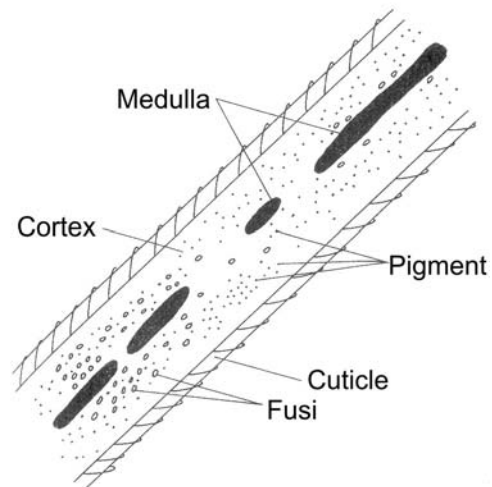


Figure H-2. Cross section of a hair shaft. Reference: Bisbing, Richard E., in Saferstein, Editor, **Forensic Science Handbook**, Vol. 1, 2nd Ed., Prentice Hall, 2002.

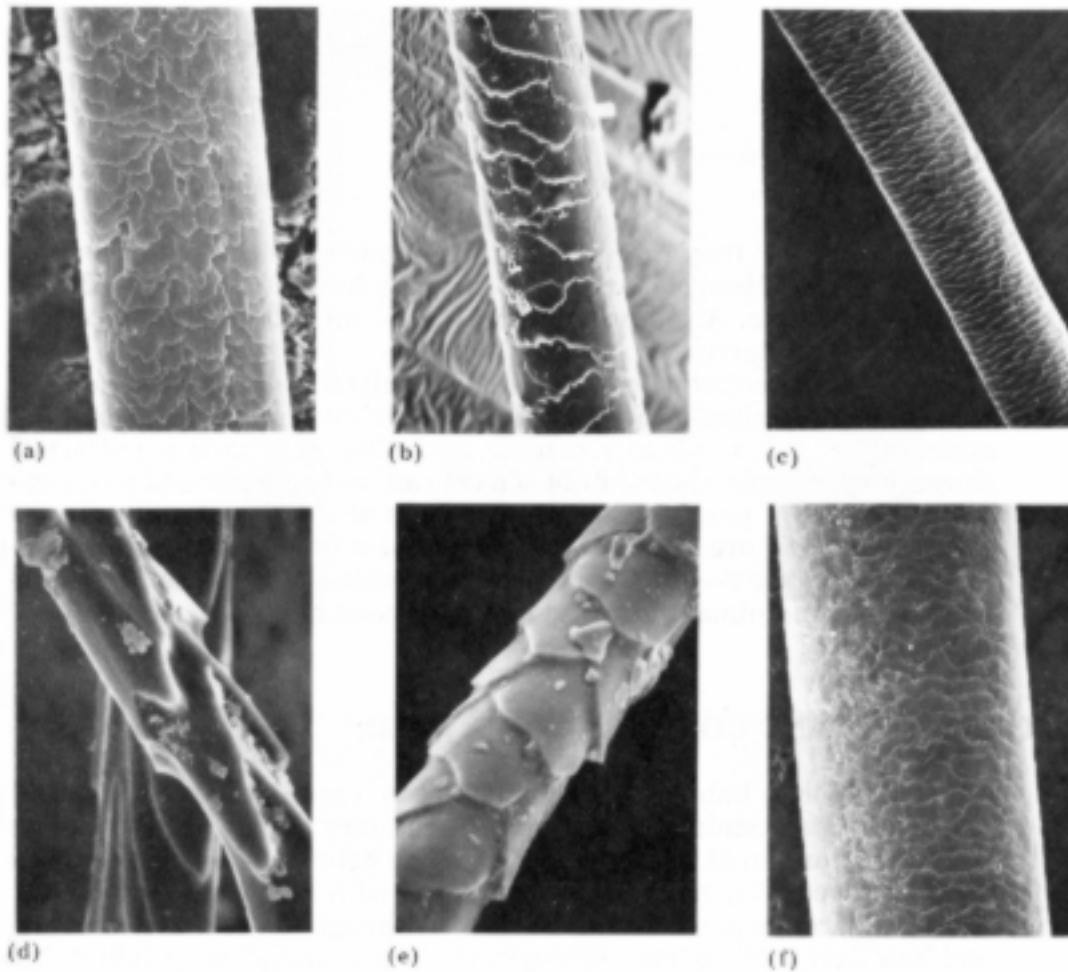


Figure H-3: Scale or cuticle patterns of several different kinds of hair. (a) Human head hair (600x), (b) dog fur (1250x), (c) Deer hair (120x), (d) Rabbit fur (300x), (e) Cat fur (2000x), (f) Horse hair (450x). Reproduced from Saferstein, **Criminalistics**, 5th Ed., Prentice Hall, 1995

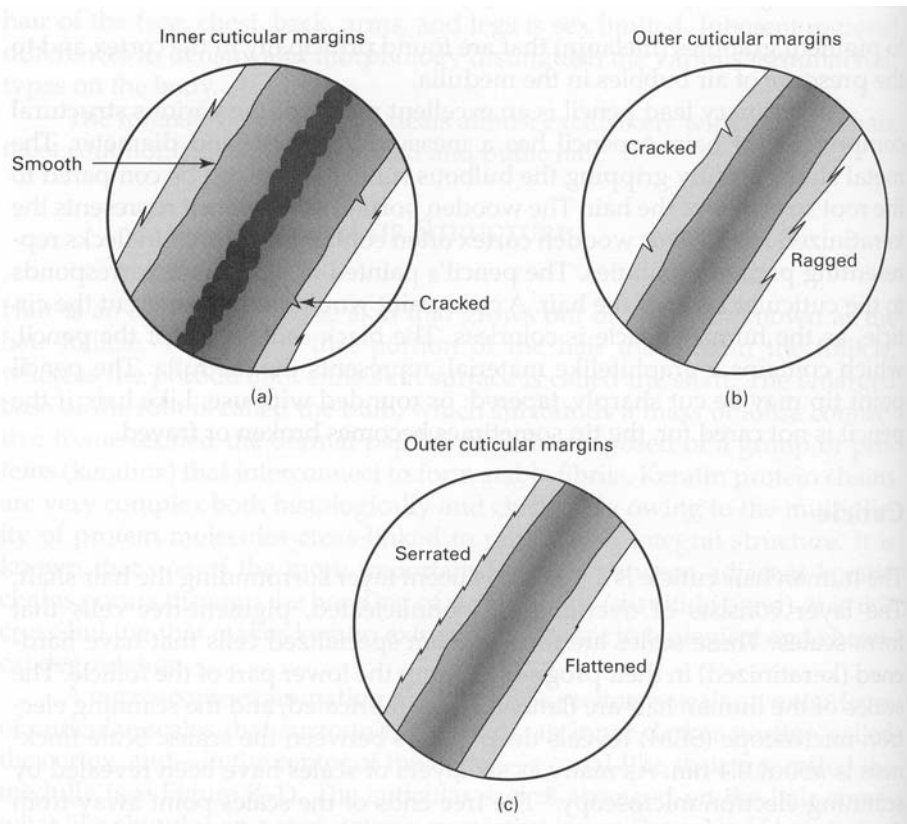


Figure H-4. Cuticular margins of human hair. Reference: Bisbing, Richard E., in Saferstein, Editor, **Forensic Science Handbook**, Vol. 1, 2nd Ed., Prentice Hall, 2002.

The medulla patterns of animals may be broad, occupying more than half of the shaft diameter.

Human head hair medulla patterns may be classified as absent, fragmental, interrupted, or continuous. (See Figure H-6).

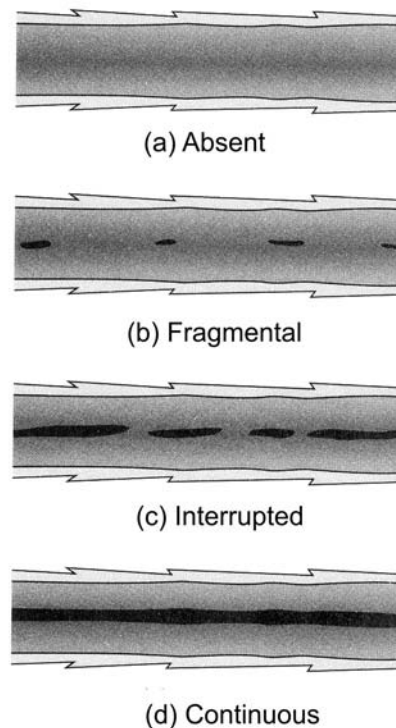


Figure H-6. Human head hair medulla patterns. Reference: Bisbing, Richard E., in Saferstein, Editor, **Forensic Science Handbook**, Vol. 1, 2nd Ed., Prentice Hall, 2002.

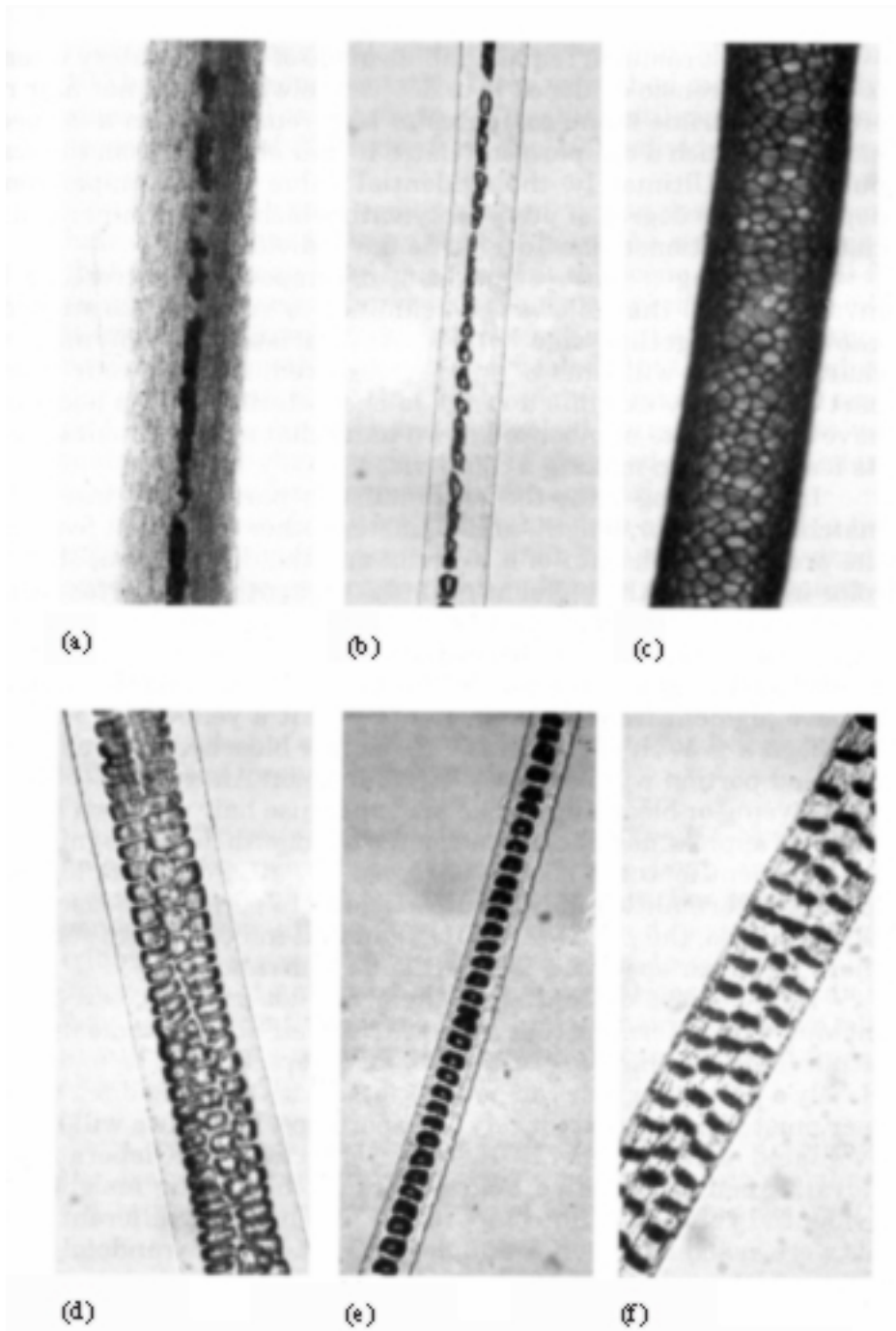


Figure H-5. Medulla patterns from different types of hair. (a) Human head hair (450x), (b) dog fur (450x), (c) Deer hair (100x), (d) Rabbit fur (450x), (e) Cat fur (450x), (f) Mouse hair (450x). Reproduced from Saferstein, *Criminalistics*, 5th Ed., Prentice Hall, 1995

Hair identification consists of determining the species, racial origin, and body or somatic location.

Species origin can readily be distinguished from the cuticle and medulla characteristics. (See Figures H-3 and H-5).

Three racial groups are used in forensic investigations: Caucasoid, Mongoloid, and Negroid. (See Table H-1)

| Race | Includes | Diameter | Cross Section | Pigmentation | Cuticle | Undulation |
|-------------|---|----------------------|----------------------|---------------------|----------------|-------------------|
| Negroid | Blacks | 60-90 μm | Flat | Dense and clumped | — | Prevalent |
| Caucasoid | American, European, Mexican, and Middle Eastern | 70-100 μm | Oval | Evenly distributed | Medium | Uncommon |
| Mongoloid | Orientals and American Indian | 90-120 μm | Round | Dense auburn | Thick | Never |

Table H-1. Racial characteristics of hair. Reference: Bisbing, Richard E., in Saferstein, Editor, **Forensic Science Handbook**, Vol. 1, 2nd Ed., Prentice Hall, 2002.

Before a comparison of hair can be made, it must be determined which portion of the body the hair originated from. (See Table H-2)

| Area of Body | Characteristics |
|--------------|--|
| Scalp | Head hair; 100-1000 mm long, 25-125 μm diameter; 0.4 mm/day growth; small root; tapered tip, little diameter variation; various medullation; often with cut tips; may be artificially treated. |
| Pubic | Pudential; 10-60 mm long; coarse diameter and prominent diameter variation and buckling; broad medulla; follicular tags common; asymmetrical cross section twisted and constricted; may be straight, curved, or spirally tufted. |
| Vulvar | Secondary public hair; finer and shorter than pubic hair; may be abraded. |
| Chest | Pectoral; moderate to considerable diameter variation; long fine archlike tip; usually longer than public hair. |
| Beard | Facial hair, very coarse; 50-300 mm long; large root irregular structure; often triangular cross section; complex medullation; blunted or razor-cut tip; grows 0.40 mm/day. |
| Axillary | Arm pit; 10-50 mm long; grows 0.30 mm/day; coarse, blunt tip, abraded or frayed; usually straighter than pubic hair; many cortical fusi; sometimes yellowed and bleached. |
| Eyebrow | Superciliary; 1 cm long; 0.16 mm/day growth; curved; relatively coarse for length; smooth curve with punctuate tip and large medulla |
| Eyelash | Ciliary; less than 1 cm long; short curved pointed hair. |
| Limb | Leg and arm hair; 3-6 mm long; fine tip irregularly medullated; often indistinctly and slightly pigmented. |
| Ear | Tragi, pinnae; downy. |
| Buttocks | Anal hair; short blunted and abraded hair. |
| Nose | Similar to facial hair (beard) |

Table H-2. Types of body hair. Reference: Bisbing, Richard E., in Saferstein, Editor, **Forensic Science Handbook**, Vol. 1, 2nd Ed., Prentice Hall, 2002.

Hair Analysis

Materials:

- Hair samples (human and animal hair)
- Microscope, 100x to 400x
- Microscope slides
- Clear nail polish
- Forceps
- Optional: Glycerin
- Optional: cover slip

Safety Precautions

The vapors from the clear nail polish are toxic. Work in a well ventilated space and keep all containers closed when not in use.

If any clear nail polish gets on your skin, let it dry and remove it with a small amount of acetone (nail polish remover).

Procedure

Hair is best examined using a microscope at 200 to 800x. (Oil immersion, 1000x, is not recommended.) At higher magnifications, the depth of field of viewing is reduced.

To examine a sample of hair, place a small amount of clear nail polish on a microscope slide and allow it to partially dry. Lay the hair on the damp nail polish. This will make a quick mount for microscopic analysis. Allow the nail polish to dry before viewing the hair sample. Adjust the microscope to 100x to locate the hair for viewing. Once the hair is centered in the view of the objective and focused, increase the magnification to 200x, 300x, 400x, or 800x. You should be able to view the cortex and medulla of the hair.

Alternatively, you can make a wet mount of a hair sample by placing a drop of glycerin on the hair and placing a cover slip on it.

If a hair has simply fallen out from a follicle, the root of the hair should be visible at one end and may taper to almost a point at the other end. If the hair has been cut, then the end where it was cut will show a flat or blunt end. If the hair has been pulled out, as in a struggle, then some of the follicle should be attached to the root.

Collect hairs of different colors from individuals in the room and compare them.

To view the cuticle structure of a hair, place a small amount of clear nail polish on a microscope slide and allow it to partially dry. Lay the hair on the damp nail polish. (The hair should not sink into the nail polish. If it does, the polish is still too wet. Allow the polish to dry some more, then try another hair sample.) Allow the polish to just barely dry (It may still have a tacky surface), then carefully lift the hair off of the dried polish. An impression of the hair remains in the polish. Adjust the microscope to 100x to locate the hair impression for viewing. Once the impression is centered in the view of the objective and focused, increase the magnification to 300x or 400x. Adjust the fine focus up and down slightly to best view the impression of the cuticle surface of the hair.

The impression is best viewed by reducing the illumination on the slide to produce what is known as a dark field, creating shadows of the hair impression.

Compare human hair with dog hair, cat hair, and hair from any other pet or animal which may be available.

For each hair used, note the color and structure. Draw a sketch of the different hairs you examined, showing both the hair structure, medulla, and the cuticle structure.

FORENSICS

Data and Results

Name _____ Course and Section _____

Partner(s) _____ Date _____

Hair Analysis

Compare human hair with dog hair, cat hair, and hair from any other pet or animal which was available. Draw sketches of the different hairs you examined, showing both the hair and the cuticle structure. Note any distinguishing characteristics of the hair samples.

Can you discern the difference between different samples of hair? Explain.