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1. Learning Outcomes

After studying this module, you will be able to know-

- About hair as evidence
- About use of microscopy for hair examination

2. Introduction

Follicles are present in the skin or dermis from which protein filaments grow. These protein filaments is known as hair. Human body is covered with skin and hair follicles within the skin. These follicles produce both thick and fine hair depending upon the location of hair on the body. Hair is composed of protein called keratin and is an important biomaterial.

Hair is one of the common and important physical evidence encountered in a crime scene. Individualization of human hair i.e. whether it is from head or body. Forceful removal of hair may have blood or skin with the root. In such cases DNA typing can be done. There have been advancement in the DNA typing technology. Earlier only hair strand with root attached could be used for typing but now with advanced technology hair without root can also be used if there are enough number of hair strands.

In absence of root, blood or any material through which typing can be done, appearance (morphology) i.e. structure and color of the hair becomes the most characteristic forensic feature of hair. Proper collection and examination of hair can provide strong corroborative evidence. Differentiation between cut, forcibly removed or fallen hair can be made easily.

Hair is an appendage of skin that grows from hair follicle. It has root (bulb or knob), a shaft and a tip. The portion of hair that lies in the follicle is known as root. Root is surrounded by loose connective tissues known as root sheath. It lies in dermis. The shaft grows and projects out of the skin. Distal end of the shaft is known as tip. Vacuoles or air bubbles are present in hair. It consists of three zones: Cuticle, Cortex and Medulla. Examination of these three zones of hair is done for identification and comparison of hair. Simple microscope can be used to observe hair and its characteristics.

3. Forensic Importance

Mutual transfer of hair due to contact is a classic example of Locard's principle of mutual exchange of traces. Hair, if properly searched are found in large number of cases. It is one of the earliest types of physical evidence which was considered, collected, evaluated and utilised in forensic work. Individualisation of hair with regard to its source has been eluding the scientist up till recently.

The identification of hair is not conclusive at the present stage of development except through DNA typing, if root hair are present or through mitochondrial protein analysis. In extremely rare cases, presence of some individual dye, contamination, some extraordinary defect or disease in the hair, however, may permit individualisation of the source, on the other hand, it is possible to exclude some persons as the possible sources of questioned hair. This exclusion, the possible corroboration and its identification, now, with new techniques, make the hair evidence one of the important pieces of physical evidence.

The evidence establishes the possible presence of culprit at the scene of occurrence. It indicates the contact if transfer of hairs has taken place. It indicates the routes of ingress or egress if some hair are retained a point of entrance or exit. It helps to identify the vehicle used in the commission of crime. It may also establish the ownership of the articles left at the crime scene.

The hair evidence is often not easily seen. Hence it goes unnoticed and it does not bother the culprit. Yet if they carry blood or blood cells, through DNA typing they permit definite identification of the culprit. Hair evaluations have also been utilized to determine the nature, quantity and the period over which the poison had been administered in slow poisoning cases. In case of Napoleon, the nature and quantity was determined after about 140 years.

The hair evidence as corroboratory evidence is available in most of the serious cases, especially in offences against person. Every human being sheds hair, normally about 10 hairs a day. The falling rate, if person is under emotional stress such as in rape or murder attempts, increases. The hair are, therefore, likely to fall at the scene. They can form important corroboratory link if collected properly. The hair are ordinarily available in murders, assaults, road accidents, rapes, abortions, bestiality, house breaking, maiming, poaching, worrying and thefts of fur and animals. Identification of hair is not an easy task.

Extensive experience is required in this field as there as variations in the hairs of same person at some as well as at different times. Further, there are similarities in the hair of the some persons. However, recent advances, especially in DNA typing of hair root cells and mitochondrial proteins hold promise for definite acceptable conditions, whenever body cells are available.

4. Microscopic examination of Hair

Light microscopy is used for examination of human hairs in forensic laboratory. Two steps are followed in this examination: identification of questioned hairs and comparison of questioned and known hair. Microscopic examination is conducted to analyse whether two or more individuals came in contact or a person came in contact with an object.

The value of hair evidence is related to the variability of hair characteristics between individuals in the population, which can be visualized through the use of comparison microscopy.

Various factors affect the reliability of hair association which includes experience training, adequacy of equipment and suitability of known hair standards. Although hair evidence is a valuable tool in human identification, it is difficult to establish a statistical probability for a particular association due in part to the lack of reliable quantitative assessments of the microscopic characteristics present in hairs.

Two compound light microscopes are connected by an optical bridge in comparison microscope which helps in simultaneous viewing of questioned and know hairs. A glass microscopic slide with known or reference hair sample is placed on the stage of other microscope. This helps in comparison of microscopic characteristics of known and questioned samples. The range of magnification commonly used is approximately 40X to 400X.

Various steps are involved in examination of hairs. First examination is to check whether the hair belongs to human or animal. If it belongs to animal, then which animal it is possible to identify the animal. Although certain hairs can be attributed to species, it is not possible to identify hairs to a specific animal to the exclusion of other similar animals.

➢ **DIFFERENCE BETWEEN HUMAN AND ANIMAL HAIR**

Following characteristics are observed when microscopic examination of hair is done to check whether the hair belongs to human and animal.

S.no.	Characteristic	Human Hair	Animal Hair
1.	Cuticle	Scale are small, flattened and surround the shaft completely.	Scales are large, polyhedral, wavy and do not surround the shaft completely
2.	Medulla	Narrow, may be absent, fragmented or discontinuous	Broad, always present and continuous.
3.	Cortex	Thick, 4 to 10 times broad as medulla	Thin, rarely more than twice the breath of medulla.
4.	Medullary Index	Less than 0.3	More than 0.5
5.	Pigment	More towards the periphery of cortex	Uniform, peripheral or central

4.1 Various types of microscopes used for hair examination

Presence of blood or debris on hair samples may be significant. In case the material adhered is of evidentiary value then it should be removed and preserved. If it does not have any evidentiary value then the hair can be washed and cleaned before mounting it. Presence of small amount of debris or blood on hair may not interfere with the microscopic examination. Cleaned and washed hair should be dried before mounting it. Those hair samples which show thermal or mechanical damage may be more brittle and should be handled carefully.

Various types of microscopes are used for examination of hair. These are:

- **Stereomicroscope**

For initial examination of mounted or unmounted hairs stereomicroscopes are used with magnification range of upto 100X.

- **Transmitted Light Microscope**

For identification and examination of hair high quality transmitted light microscope is required. The objectives and eyepieces should permit observations in the range of approximately 40X to 400X. Examiner's ability to observe certain features is enhanced by using a polarized light microscope.

- **Comparison Microscope**

While comparing microscopic characteristics of hairs, high quality transmitted light microscope is necessary. High quality objectives are important. The objectives and eyepieces selected should permit observations in the range of approximately 40X to 400X. A high-intensity tungsten light source, suitable for photomicrography and equipped with a daylight correction filter which is present for providing adequate lighting. Both sides of a comparison microscope should be balanced for light intensity and color. A comparison microscope may be equipped with one of several types of stages.

4.2 Observations of microscopic examination

Preliminary microscopic examination is carried out without cleaning or mounting the hairs. It reveals their color, contamination and character whether they are curly, wavy, soft or coarse, whether the ends are frayed or have tips or whether roots are present or not. It is possible to say whether the hair have been pulled out, cut or fallen. Pulled out hair have live bulbs and signs of stretching near the bulb while the fallen hairs the root bulbs are found shrunken. The detailed microscopic examination of hairs is done after cleaning them in alcohol-ether mixture (or acetone). They are then mounted in Canada Balsam on a microscopic slide and examined with a magnification of about 400X.

The examination reveals:

- Actual color of hairs. The contamination which may be masking the real color of the hairs is removed in the cleaning process.

- Whether the hairs have been dyed or bleached. Natural color of hair is found near the root end. This portion of hair may be long or short depending upon the period elapsed between the dyeing or bleaching and collection (From the head or fallen hair) of the hairs from examination.

- The part of the body from which the hairs have come. The head hairs are like rods, whereas the hairs from eyebrows or eyelashes have pointed tips. The beard hair may be somewhat flattened.

- The morphology of the hair. It indicates the presence or absence and nature of the medulla and the pigmentation pattern.

- The Medullary Index. The ratio of diameters of the medulla and the hair measured at the thickest point is known as medullary index. Its determination establishes the species of origin. The medullary index of the human hair is commonly less than 0.3 and in animals generally it is more than 0.5.

  Medullary index varies somewhat in male and female hairs and in the hairs from different parts of the body. Ordinarily, the medullary index is greater in woman when hair from the corresponding parts of the body are compared. The male beard hairs have greater medullary index than hairs from other parts.

  Medulla may be continuous, fragmentary or it may be absent in human beings. It may be masked sometimes by the hair pigment. It is made visible by bleaching the hair.

- Pigmentation distribution. It is helpful in the study of species of origin and in the identification of hairs of an individual. It is often an important characteristic and permits elimination of certain suspected sources of hairs.

- The roots and the ends. They reveal whether the hair have been pulled out or not. Whether they have been cut and if so when they were last cut. When tips are freshly cut they have sharp cut ends. With the passage of time, the sharp ends gradually become round. The possible nature of weapon with which the hair has been severed is also revealed. With blunt weapons the cut end is found frayed and irregular. With sharp edged instrument the cut ends have sharp edges.

- Any deformity or disease in the hair.

- Vacuoles. They give characteristic formations in certain species which are useful in their identification. They are also known as air bubbles.

- The special treatment (for example, burning) hairs may have undergone.

5. Microtomy

The cross sections of hairs are obtained with the help of an instrument called microtome, clean hair is embedded in hard wax, plastics or flesh (hardened by special treatment) and sliced. The cross sections of hairs, obtained, are placed on a microscope slide treated with albumen. The embedding material is removed with a suitable solvent and the sections are fixed in Canada Balsam. Microscopy reveals the cross sectional structure of hair.

Microtomy is helpful to determine pigment distribution, medullary shape and medullary index of the hair. In human hair the pigment is found concentrated near the periphery of the cortex close to cuticles while in animals, pigment concentration are near the medulla and in the cortex. It also permits proper study of the shape of cross sectional area.

6. Summary

- Hair is composed of protein called keratin and is an important biomaterial.
- Hair is one of the common and important physical evidence encountered in a crime scene.
- In absence of root, blood or any material through which typing can be done, appearance (morphology) i.e. structure and color of the hair becomes the most characteristic forensic feature of hair.
- The hair evidence as corroboratory evidence is available in most of the serious cases, especially in offences against person.
- First examination is to check whether the hair belongs to human or animal. If it belongs to animal, then which animal it is possible to identify the animal. Although certain hairs can be attributed to species, it is not possible to identify hairs to a specific animal to the exclusion of other similar animals.
- Presence of small amount of debris or blood on hair may not interfere with the microscopic examination. Cleaned and washed hair should be dried before mounting it.
- Light microscopy is used for examination of human hairs in forensic laboratory.
- Microscopic examination is conducted to analyse whether two or more individuals came in contact or a person came in contact with an object.
- Two compound light microscopes are connected by an optical bridge in comparison microscope which helps in simultaneous viewing of questioned and know hairs.
- The range of magnification commonly used is approximately 40X to 400X.

- Microscopic examination reveals their color, contamination and character whether they are curly, wavy, soft or coarse, whether the ends are frayed or have tips or whether roots are present or not.

- The ratio of diameters of the medulla and the hair measured at the thickest point is known as medullary index.

- Vacuoles give characteristic formations in certain species which are useful in their identification. They are also known as air bubbles.

- The cross sections of hairs are obtained with the help of an instrument called microtome.

- Clean hair is embedded in hard wax, plastics or flesh (hardened by special treatment) and sliced.

- Microtomy is helpful to determine pigment distribution, medullary shape and medullary index of the hair.