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HAIR SUGGESTS HEIR OF DNA ANALYTICAL REPORT IN FORENSIC SCIENCE CRIME SCENE

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ABSTRACT
Locard exchange principle says that "every contact leaves a trace." Hair analysis can be used for the determination of drug use months after drug consumption, hair analysis data can often act as important and even decisive evidence in the courtroom. Hair analysis has been receiving increased attention during years and, currently, it has become the third most fundamental biological matrix used for drug testing in forensic toxicology, after blood and urine.

The aim of this chapter is to review, summarize, and discuss different applications of hair analysis in forensic toxicology, based on the bibliography and on the experience of a forensic toxicological laboratory. They include, among others:
•Postmortem cases;
• Putrefied or even mummified cadavers, when other biological samples are not available;
•To clarify the cause of death;
•Loss of tolerance after a period of abstinence;
•Multiorgan damage caused by long-term consumption;
•Drug-facilitated crimes (DFCs);
•Drug-facilitated sexual assaults (DFSA);
•DFC in elder people;
•DFC in children;
•Divorce and child custody proceedings;
•Follow-up of detoxification programs.

KEYWORDS: Follicles, morphology, Cuticle, cortex, Caucasian race, medulla, capillary section, forensics, depigmented, medullary ratio, wavy, toxicology, radioimmunoassay, enzyme-linked immunosorbent assay, curly, length, ancestral lineage, races, preservation, analysis, collection, analysis, non-invasive procedure, fibrils.

INTRODUCTION
Hair is one of the defining characteristics of mammals. The human body, apart from areas of glorious skin, is covered in follicles which produce thick terminal and fine vellus hair**.** The most basic components of hair are keratin, a very strong protein that is resistant to decomposition, and melanin, a pigment. The keratins form groups that interact and interconnect to form very stable fibrils. It is this property of hair that makes it such a prime example of physical evidence. Nowadays, the properties and functions of hair are social, sexual and psychological.[1]

On the other hand, the hair functions related to protection from external agents or thermoregulation. Hair length also varies greatly from person to person. The average length is never more than one meter. It must be noted however that hair can exceed this length in certain individuals. We can distinguish between three types of hair according to shape, according to the appearance that the shaft may take at the base and according to its capillary section, which is determined genetically.

Hair may, therefore, be:
1) cymotrichous: wavy or curly in oval sections, typical of Caucasian races (Europeans);
2) leiotrichous: smooth in round sections, typical of Mongoloid races (Asians);
3) ulotrichous: woolly and dry in flat sections, typical of black ethnicities (Africans).

HAIR MORPHOLOGY

Hairs are dead, cornified cells. The portion existing above the epidermis is called the shaft; below the epidermis, the root is embedded in the hair follicle. The hair shaft is composed of three layers: − Outer cuticle − Cortex − Central medulla Cuticle.[2,3]

CUTICLE

The cuticle of a hair is the thin, translucent layer surrounding the shaft. It consists of scales of hardened, keratinized tissue that vary from species to species, and includes such patterns as: –

1) Coronal, or "crown – like." Rare in humans; typical of rodents. Found in hairs of very fine diameter. – 2) Spinous, or "petal – like." Never found in humans. Common in cats, seals, and minks.

3) Imbricate, or "flattened." Common in humans.

Figure-1: Types of hair.

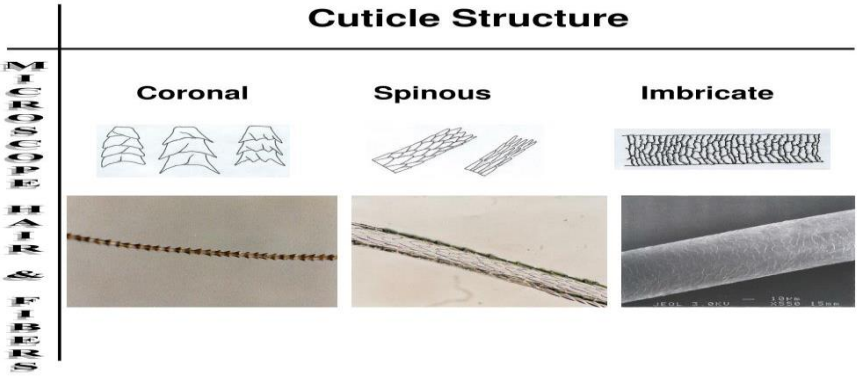

Figure-2: Cuticle.

CORTEX

The cortex is the main body of the hair, composed of spindleshaped cortical cells.

• Contains pigment bodies, which contains the melanin (hair color) and cortical fusi. – Cortical fusi are air spaces of varying sizes found near the root of a mature human hair. – Pigment granules are small, dark, granulated structures that vary in size, color, and distribution. Typically distributed toward the cuticle in humans.[2]

- Bleached hair is devoid of pigment granules, and dyed hair has dye in the cuticle and the cortex.
- When you stretch the hair, you are coiling the stretch the coiled proteins of the hair in the cortex. When you release the strand, the proteins get coiled up again. The pigments which give natural colour to the hair are coiled up in deep fold of the protein & protected from the elements by translucent layer of cuticle.
- The cortex can't heal itself on its own that is why there are no other option excepting chopping the split ends of. Split ends result due to the worst condition of the cortex.[2]

MEDULLA

The medulla is the innermost layer of the hair shaft. This nearly invisible layer is the most soft and fragile, and serves as the pith or marrow of the hair. Scientists are still uncertain about the exact role of the medulla, but they speculate that it is primarily an extension that is more prominent in depigmented (grey or white) hair.[17]

The medulla may be:

– Continuous– ; Fragmented–; Interrupted.[17]

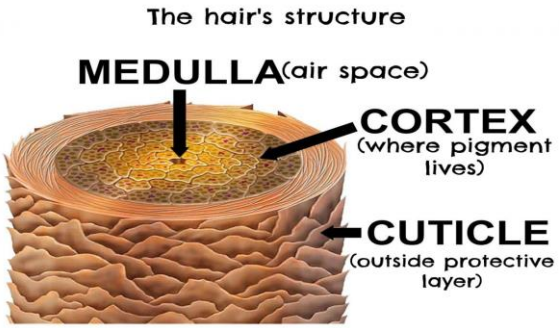

Figure-3: Hair anatomy.

HAIR FORENSICS

Hair evidence is easily transferred to and from the crime scene. • Collection should be done by hand if the location of the hair is important, which is usually the case. Sticky tape and lint rollers may be used to assist. • A special filtered vacuum cleaner may be used to collect hairs and fibers en masse from carpet, bedding, etc. • If the evidence is stuck to another object, the entire object should be packaged and labeled. Often it is not possible to extract DNA fully, or there is not enough tissue [present to conduct an examination. Hairs with large roots & tissue are promising source of nuclear DNA. However, DNA examinations destroy hairs, eliminating the possibility of further microscopic examination.[6]

FOREIGN ANALYSIS OF THE HAIRS

Humans hairs can be separated from animal hairs in any number of ways, including the medullary ratio, characteristics of the medulla, and the scale patterns of the cuticle.

• Different species of animals can be identified quite easily using the same basic principles.

• The next step tries to classify the racial origin of the hair as: negroid, mongoloid, and Caucasian, typically using head hair. Mixed individuals sometimes exhibit properties of all of their ancestral lineage, and make classification difficult

Somatic regions can be determined based on the hair's morphology, such as: – Head hairs have a soft texture, cut or split tips, and moderate shaft diameter.

– Pubic hairs have a course, wiry texture, tapered, rounded, or abraded tips, and a buckling shaft.

– Facial hairs have a triangular cross-section and a course in texture.

– Eyelash/Eyebrow hairs are saberlike in appearance, short, and stubby.

– Limb hairs are soft, and arc-like in appearance. Tips are rounded and abraded; scales rounded due to wear.[12]

Figure-4: Sectional view of Hair.

ANALYSIS METHODS

The radioimmunoassay and enzyme-linked immunosorbent assay are two common assays that are used by forensic toxicologists to detect substances such as drugs in the hair.

• The immunoassays function on the basis of an antigen-antibody interaction. The analyte, or drug, is added and binds to the solid phase, typically producing a color change, fluorescence, etc. that can be measured to determine the amount of drug present.

• Forensic toxicologists also look for toxic metals in the hair to explain poor mental and physical health. How an ELISA functions Forensic Analysis of the Hair.

Individualization has been impossible to obtain with hairs in the past, but recent techniques are making it more realistic.[14]

• Nuclear DNA (n-DNA) and mitochondrial DNA (mt-DNA) can be extracted from the root or follicular tag of an anagenic hair. Nuclear DNA comes from both parents; mitochondrial DNA is passed only from mother to offspring.

• Nuclear DNA can lead to individualization. Odds created by association of a suspect with evidential hairs are typically one to billions or trillions.[12,13]

FORENSIC ANALYSIS METHODS

Using a microscope (SEM), forensic scientists can typically determine the species, race, and somatic origin of a hair. They may use comparative microscopy to do one of the following: – Link the suspect to a crime scene, meaning that a control hair matches the evidential hair. – Exclude the suspect from a crime scene, meaning that a control hair does not match the evidential hair. • In addition to comparing hairs in with a microscope, the scientists may test for DNA on the follicular tag, and run a number of tests for drugs and environmental toxins, which will be described at length.

Figure-5: Hair MRI.

Hair analysis is used in forensic toxicology to test and determine whether a drug was used.

• When a drug is ingested, it enters the blood stream and is broken down to a specific metabolite.

• Hair strands normally grow at an average rate of 1.3 centimeters every month; they absorb metabolized drugs that are fed to the hair follicle through the blood stream.

• The drug will only disappear if exposure to the drug is ceased, and the hair containing the drug is cut.

• Hair analysis can be used for the detection of many therapeutic drugs and recreational drugs, including cocaine, heroin, benzodiazepines (Valium-type drugs) and amphetamines.[6]

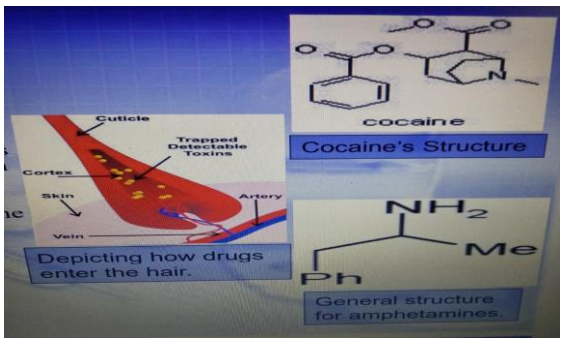

Figure-6: Effects of drug on hair.

Collection &; Preservation of Hair Evidence: If sticky tape or a lint roller are used, the entire surface used should be packed into a polyethylene storage bag – easy to see through, but with no direct contact.

• Control samples need to be collected from the victim, suspect, and other individuals who could have left evidence at the scene. Take from all pertinent regions of the body; 50 head hairs, 24 pubic hairs. Root still intact is preferable.

Hairs found at the crime scene are compared to samples from the victim and from the suspects. 50 full-length hairs from all areas of the scalp may be collected as samples. Use a piece of tape to collect and package hair samples from a crime scene.[4,5]

Figure-7: Hair investigation.

Figure-8: Effects of drugs on hair.

Hair Forensics: Head hairs and pubic hairs exhibit a greater range of microscopic characteristics than other human hairs; therefore, head and pubic hairs are routinely forensically compared. Twenty-five randomly selected head hairs are generally considered adequate to represent the range of hair characteristics of that individual. It is recommended that the same number of hairs be collected from the pubic region.

Forensic Identification: Human hairs can generally be identified by racial origin, body area, and other comparison characteristics. Racial indicators apply primarily to head hairs. Hair Shape and texture: Shape – round, crescent or oval cross- section. Texture – curly, wavy, straight, kinky influenced heavily by genes.[13]

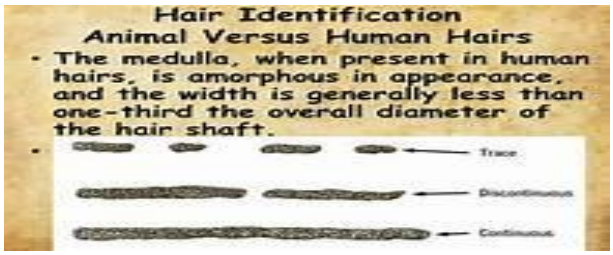

Figure-9: Hair shape.

African American Hairs
- Curly.
- Dense pigment distributed unevenly.
- Variations in the diameter of the shaft.
- Fragmented or absent medullae
- The cross-section is flattened.

Asian and Hispanic Hairs
- Coarse and straight shaft, with little diameter variation
- Dense pigment distributed unevenly.
- Presence of a continuous medulla.
- The cross-section is round.

Caucasian Hairs
- Straight to wavy.
- Fairly evenly distributed, fine pigment.
- Moderate shaft diameter, with little variation.
- The cross-section is oval.[7,8]

Properties	Asian (mongoloid)	Caucasian (europoid)	African (negroid)
Hair shape	Straight / Soft	Soft / Wavy	Kinky / Coily
Maximum length	100 - 150 cm	60 - 100 cm	15 - 30 cm
Average density	175 g / cm²	330 g / cm²	295 g / cm²
Tensile resistance	60 - 65 g	40 - 45 g	30 - 35 g
Hair section	Round	Oval	Flat
Cystine (um/g)	1175 - 1357	1268 - 1608	1310 - 1420
Resistance to tension	Resistant	+ or - resistant	Fragile (easy breakage)

Figure-10: Hair according to race.

Things to consider when viewing hair

Length: Length is considered, although hairs may have been cut between the time of deposition of the questioned specimen and the collection of a known sample. In addition, there may be a significant difference in the lengths of the shortest and longest hairs on an individuals & head.

Tip: The tip can be cut, broken, split, abraded (rounded), or finely pointed as illustrated by an individual & grooming, hygiene, health, and nutrition can affect these features. Dyed hairs possess an unnatural cast or colour. In addition, the cuticle will take on the color of the dye.[15,16]

Figure-11: Hair types.

CONCLUSION

Hair analysis for drugs is now well established in forensic toxicology. Segmental hair analysis permits retrospective information on drug exposure (single or repeated) and should be considered in the investigation of drug-facilitated crimes where there has been any appreciable delay in samples being obtained for analysis. Hair analysis can provide peculiar information due to the long window of detection, and allows past consumption estimation of a drug; moreover, hair samples are easy to collect (with noninvasive procedures) and store. For these reasons, interest in this matrix has increased over the years resulting in an increment of publications for a wide range of purposes (such as multidrug screening, dosage after single exposure) and application fields (i.e., addiction monitoring, DFSA, postmortem). In many circumstances, hair assays have been shown to be approximately correlated to ordinal levels of use.

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