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Forensic Analysis of Human Hair: Advanced Methods for Identification, Interpretation, and Evidentiary Value

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Abstract: *Human hair is among the most frequently encountered forms of biological trace evidence in forensic investigations due to its durability, ease of transfer, and persistence in diverse environments. This paper presents a comprehensive examination of the forensic analysis of human hair, integrating classical microscopic techniques with modern molecular approaches. The study reviews hair structure and biology, outlines standardized methods for evidence collection and laboratory examination, and evaluates the evidentiary value of morphological and DNA-based analyses. Results demonstrate that while microscopic hair examination remains a valuable tool for exclusion and preliminary assessment, its interpretive power is significantly enhanced when combined with nuclear and mitochondrial DNA profiling. The findings highlight both the strengths and limitations of forensic hair evidence and emphasize the need for cautious interpretation, standardized methodologies, and multidisciplinary integration. Advances in molecular technologies and statistical frameworks are discussed as critical pathways for improving the reliability and probative value of hair evidence in forensic casework.*

Keywords: Forensic science; Human hair; Trace evidence; Hair microscopy; DNA profiling; Mitochondrial DNA; Forensic identification

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