DNA Analysis of Hair

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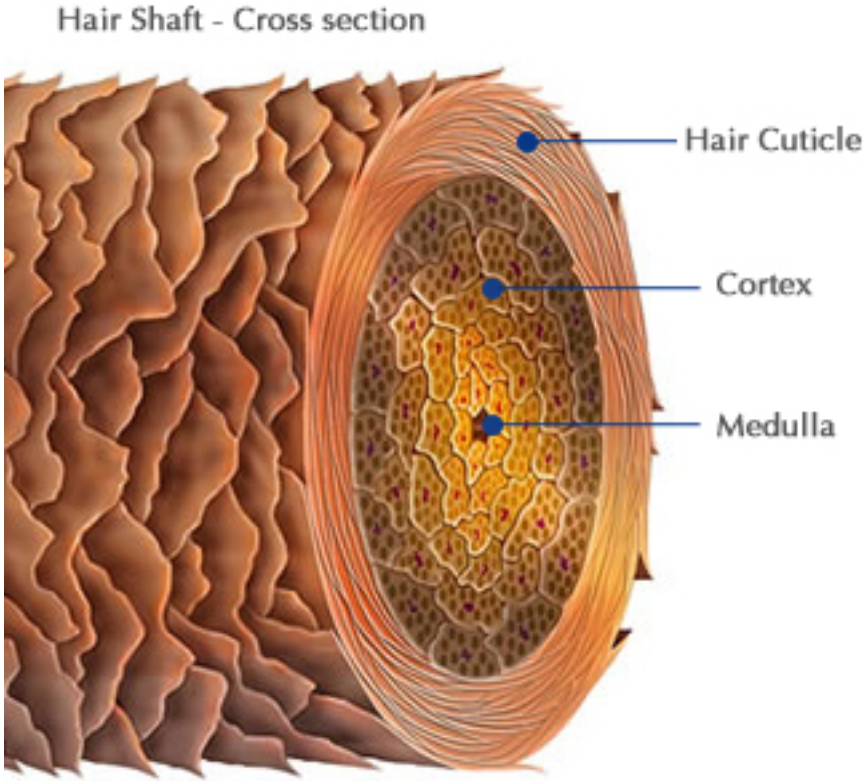
Overview

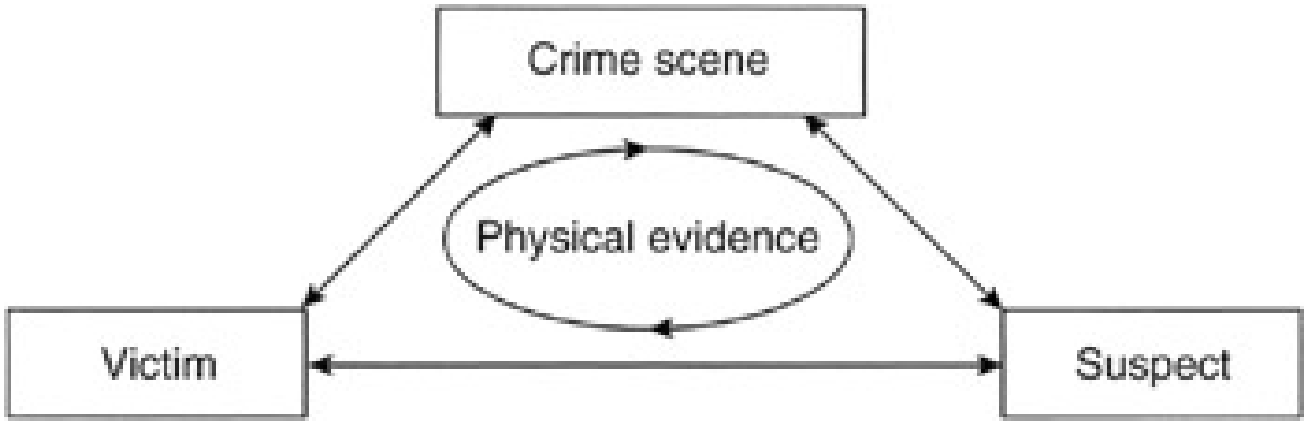
- Anatomy of hair
- Hair as evidence
- Microscopic evaluation of hair
- Telogen vs. anagen hair
- Nuclear vs. mitochondrial DNA analysis
- Lack of nuclear DNA from hair cells
- Discussion of study regarding nuclear DNA in hair

Anatomy of Hair



Locard's Principle

- Every contact leaves a trace

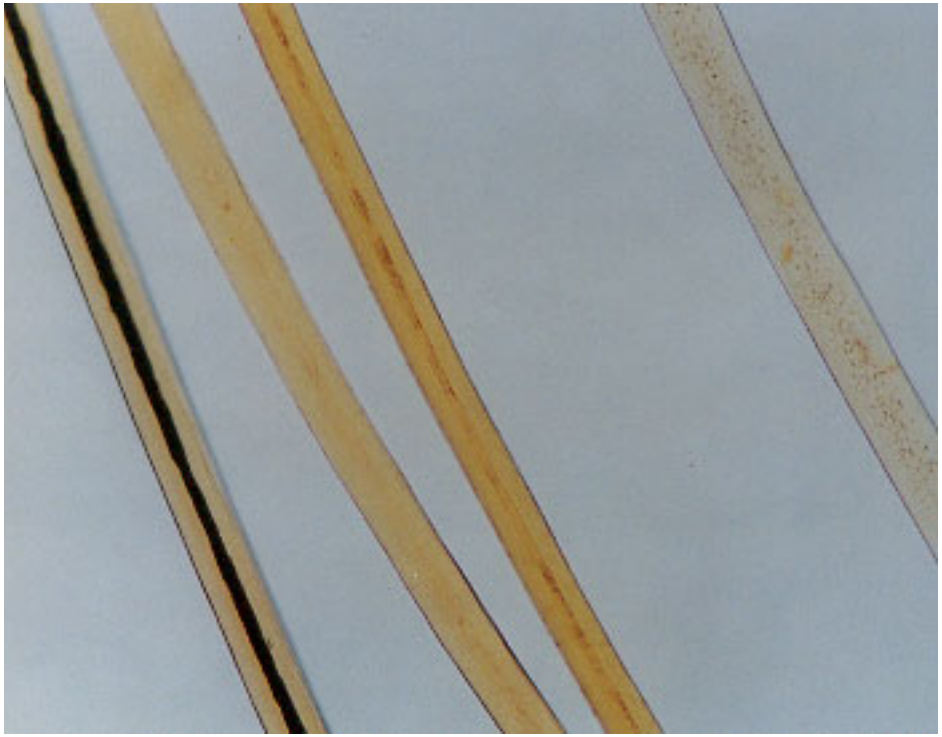


Hair as evidence

- Common form of evidence
- Can link an individual to a crime or crime scene
- The amount of hair submitted can vary greatly

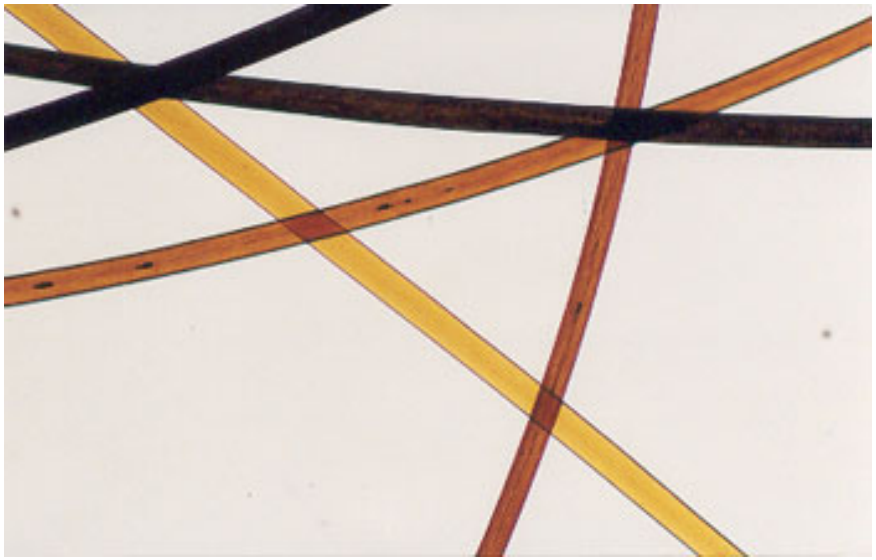
Microscopic Evaluation of Hair

- Screening method
  - Determine hair donor
  - Include/exclude for DNA analysis



Microscopic Evaluation of Hair

- Probative evidence aside from DNA
  - Ethnic characteristics
  - Origin of hair
  - Hair color
  - Artificial treatment
  - Damage



Microscopic Root Evaluation

- Root tissue? Yes.
  - Analysis of nuclear DNA
- Root tissue? No.
  - Analysis of mitochondrial DNA

Root Tissue Vs. No Root Tissue

Phases of Hair Growth

Anagen Phase Hair

- Anagen phase= active growth phase
- Involves living cells
- Plucked/shed during traumatic events
- Likely contains root tissue
- Nuclear DNA analysis

Nuclear DNA Analysis

- Unique to each individual (excluding identical twins)
- Highly discriminating
- Compatible with national databases

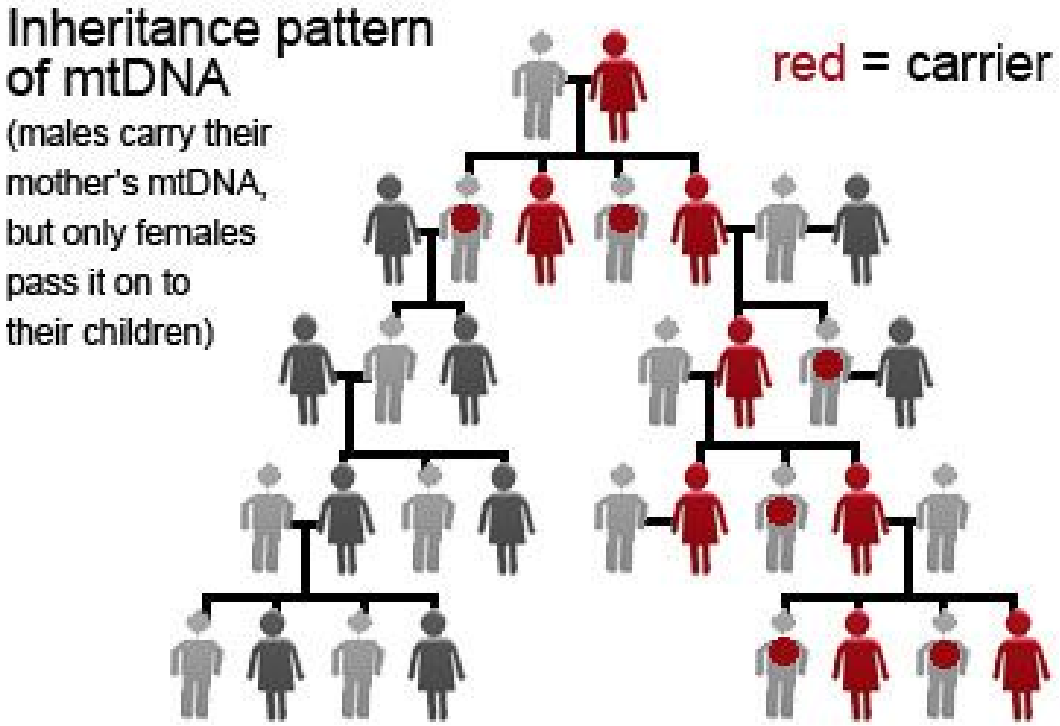
Telogen Phase Hair

- Telogen phase= resting phase
- Lacks living cells
- Naturally shed
- Likely does not contain root tissue
- Nuclear DNA analysis is inconsistent
- Mitochondrial DNA analysis

Mitochondrial DNA Analysis

- Does not require root tissue- hair shaft only
- Present in many copies within a cell
- Maternally inherited
- Can exclude individuals
- Combination of mitochondrial DNA with microscopic comparison is probative

Maternal Inheritance



Nuclear VS. Mitochondrial DNA Analysis

- Mitochondrial DNA profiles
  - Are not compatible with databases
  - Do not distinguish between maternal relatives
  - Require the hair shaft only
- Nuclear DNA profiles
  - Are compatible with databases
  - Specific to an individual
  - Require root tissue for a full profile

Why Isn't There Nuclear DNA in Hair?

- Cornification process in hair
- Activity of keratinocyte specific enzyme, DNase 1 Like 2 (DNase1L2), that degrades nuclear DNA

Cornification of Hair

- Cells move out of the zone of the hair follicle where cells are multiplying
- Cornification begins
- Accumulation of keratin in cytoplasm
- Leads to the stability of hair
- Breakdown of organelles and nucleus
- These cells die and become the dead building blocks of hair

DNase1L2 Activity

- DNase1L2 enzyme has been found to degrade nuclear DNA during cornification of hair
- Mice studies

Study of Nuclear DNA in Hair- Overview

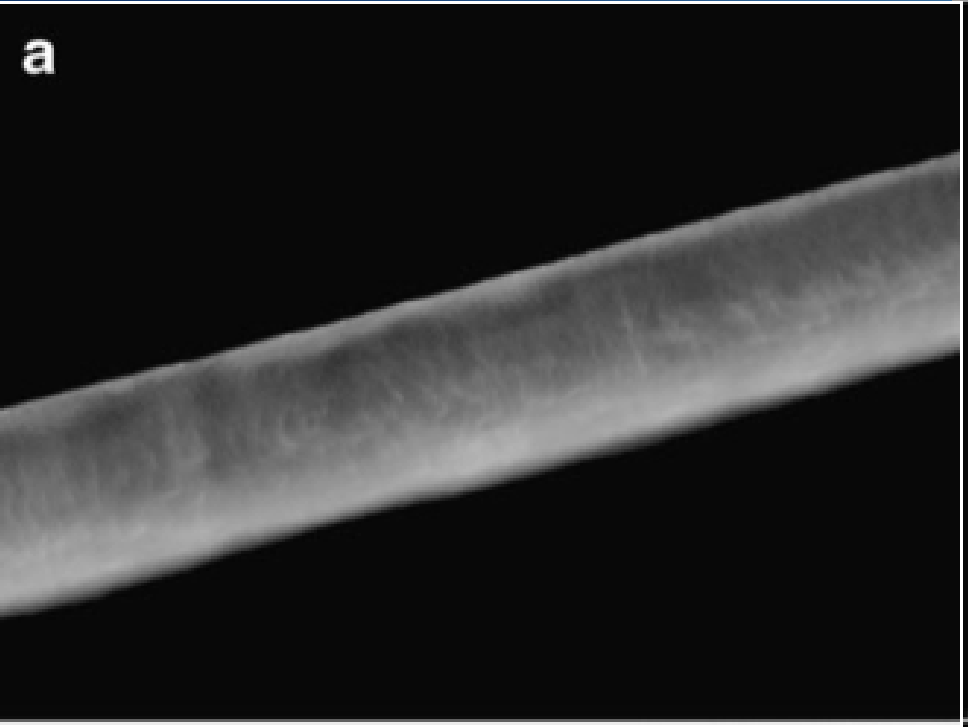
- Hair cells contain nuclear remnants that contain degraded nuclear DNA
- Degraded DNA was labeled with fluorescence and viewed under a fluorescent microscope
- Nuclear DNA analysis was performed

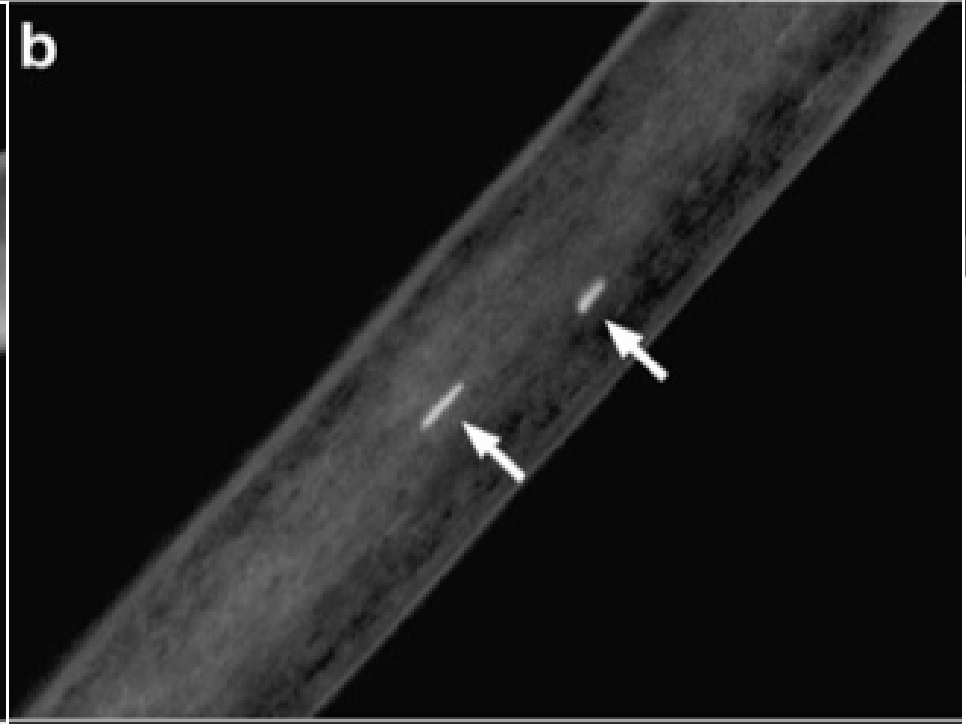
Experiment Setup

- Root tissue not included
- Hair washed so no tissue remained
- Labeled with DNA specific fluorescent dye
- Viewed under a fluorescent microscope

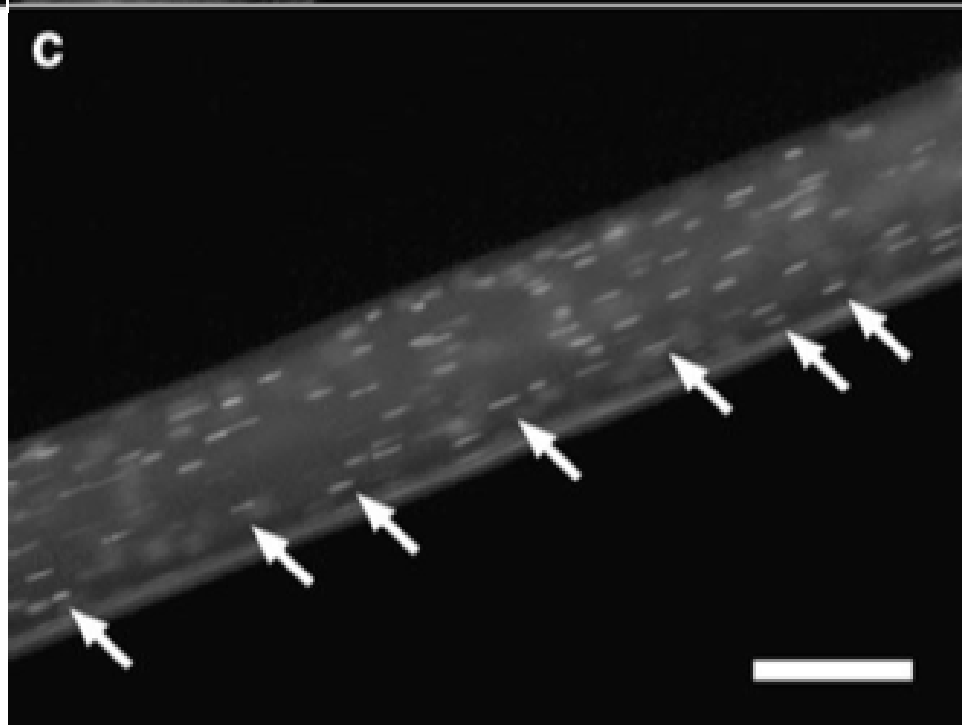
Results

- Nuclear remnants containing DNA varies between individuals: low, high, or none
- Nuclear remnants varied even between hair cells within the same individual's hair





Variation of Labeled Nuclear DNA Remnants



Variations in the Number of Nuclear Remnants Observed

- DNA positive nuclear remnants had no correlation with:
  - Hair color
  - Age of hair donor
  - Distance from the site of proliferation

Why Does the Amount of Nuclear DNA in Hair Vary?

- Attributed to degree of completion of DNA degradation by DNase1L2
- Only small portion of total hair cells contained remnants, indicating nuclear DNA is typically degraded to completion

Correlation Between Nuclear Remnants and Nuclear DNA Profile

- High correlation, whether individual hairs or pooled hair from an individual were analyzed
- All hair that lacked remnants also lacked a nuclear DNA profile
- No correlation between remnants and mitochondrial DNA analyzed- different mechanism of degradation

So, can we get nuclear DNA profiles from hair?

- Approximately 75% of hairs that contained stainable DNA had at least one locus successfully typed

- The amount of labeled nuclear DNA varies greatly from individual to individual

Conclusions

- Mitochondrial and microscopic analysis remain primary analysis types for hair
- Nuclear DNA analysis of hair would change forensic science
- More studies needed

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References

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Picture References

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Questions?