The Basis of Evidence: Transfer and Persistence

Developed by Edmund Locard, a French forensic microscopist in the early part of the 20th Century, it posits that this exchange of information occurs, even if the results are not identifiable or are too small to be found.

The results of such a transfer would be proxy data: Not the transfer itself, but the remnants of that transaction.

Because forensic science demonstrates associations between people, places, and things through the analysis of proxy data, essentially *all evidence is transfer evidence*. 
**Relationships and Context**

Victim and Criminal only interact at a Crime Scene unfamiliar to both
Ex. Sexual assault in an alley

Victim and Criminal interact at a Crime Scene familiar to both
Ex. Spouse kills co-habitating spouse

Victim and Criminal interact at a Crime Scene familiar only to the Criminal
Ex. Kidnapping and assault in Criminal’s house

Victim and Criminal interact at a Crime Scene familiar only to the Victim
Ex. Home invasion
Hairs
Basis for Method

- Anthropology
  - Study of humans
- Zoology/Mammology
  - Study of animals and mammals
- Comparative biology
  - The study of similarities and differences between taxonomic groups
- Microscopy
- Histology
What can be determined?

- Is it a hair?
- Is it human?
- What area of the body is it from?
- What is the person’s ancestry?
- Is there damage, disease, treatment?
- Is it suitable for comparison?
Is it a hair?

- Identifiable by its shape and structure
- Parts of a hair
  - Root
  - Shaft
    - Cuticle
    - Medulla
    - Cortex
  - Tip
Main parts of hair

Cuticle

Cortex

Medulla
Growth Phases

Anagen

Catagen

Telogen
Is it human?

Human
- Even shaft diameter
- Pigmentation even
- Color uniform
- Imbricate scales
- Amorphous medullation
- May be very long

Animal
- Shaft varies
- Pigment varies
- Color banding
- Varies by species
- Medullation varies with species
- Most are less than 3”
Mink
Human head hair
What is the person’s ancestry?

- African ancestry
- Asian ancestry
- European ancestry

- Estimation of ancestry based on hair characteristics may not correlate with genetic or self-identity
What area of the body is it from?

- **Head**
- **Pubic**
  - Facial
  - Limb
  - Chest
  - Axial (armpit)

These carry the most information for microscopic comparisons.
Damage/disease/treatment
Is it suitable for comparison?

- Unsuitable hairs
  - Damaged
  - Too short
  - Too light in color
  - Fragment
  - Extreme treatment
- Suitable hairs may be compared with suitable known hair samples of the same type
  - Head to head; pubic to pubic
Comparison process

- Uses a comparison microscope
  - Two microscopes optically joined
  - Split-screen view
- Two samples side-by-side simultaneously
- Use all characteristics available
- Questioned hair must fall within variation established by the Known sample
Ensemble of Class Traits

- Root
  - abundant fus
  - telogen
  - anagen
  - decomp
  - stretched
  - follicular tag
- Tip
  - cut
  - broken
  - split
  - pointed
  - round
- Width
  - coarse
  - fine
  - variation along shaft
  - variation w/in sample
- Cuticle
  - thickness
  - variation in thickness
  - clarity
  - color
- Scales
  - protrusion
  - slight
  - medium
  - great
- length
  - short
  - medium
  - long
  - thick
  - thin
  - medium
- Medulla
  - fluctuation
  - absent
  - translucent
  - fragmented
  - transparent
  - discontinuous
  - opaque
  - continuous
  - cell shape
  - thick
  - thin
  - medium
- Cortex
  - cells prominent
  - cells obscured
- Pigment
  - size of granules
  - shape of granules
  - density
  - local distribution
  - patchy
  - streaky
  - chaining
  - distribution w/in shaft
  - gapping
  - shallow
  - short
  - medium
  - deep
  - long
- Cosmetic
  - pigment in cuticle
  - bleached
  - dyed
  - length of time since treatment
- Special
  - cracked cuticle
  - ovoid bodies
  - double medulla
  - diseases
  - vermin
Conclusions

• Positive Association
  – The Q1 head hair exhibits the same microscopic characteristics as the K1 head hairs and, accordingly, could have come from the same source.
    • It should be noted that the microscopic comparison of hairs is not a method of positive identification.

• Exclusion
  – The Q1 head hair exhibits similarities to and differences from the K1 head hair sample. Accordingly, no conclusion could be made as to whether Q1 and K1 could have had a common source.

• Inconclusive
  – The Q1 head hair is microscopically dissimilar to the K1 head hair sample and, accordingly, could not have come from the same source.
Mitochondrial DNA

- Provides additional information about hairs
- Sequences mtDNA; compared against data bank
  - Maternally inherited
  - Genotype
- Microscopy = phenotype
  - Genotype + environment
- Complementary
Microscopic hair examinations and DNA examinations are complementary techniques—both are more powerful together than separate.

Microscopic examinations evaluate the observed physical characteristics (phenotype) of a hair. Molecular examinations provide information about the genotype of a hair.
Houck and Budowle, 2002

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Results of Microscopic and Mitochondrial DNA Analyses
### Mitochondrial Results

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Did the hair examiners make a mistake?

Hairs exhibit a multivariate phenotype

Many traits that overlap to a greater or lesser degree; some may not overlap with others

It’s possible but rare for more than one individual to exhibit sufficient characteristics so as to be indistinguishable from another
A five year retrospective review of mitochondrial DNA (mtDNA) analysis on 691 casework hairs was carried out. A full or partial mtDNA profile was obtained for >92% of hairs.

- With increasing age of the hair, the likelihood of obtaining a full profile decreased.
- With increasing color and diameter of the hair, the likelihood of obtaining a profile increased.
- Full or partial profiles were obtained on more than 80% of 114 hairs ≤1.0 cm. Mixtures were observed in 8.7% of hairs tested.
  - mixtures increased with the age of the hair and were presumed to be due to exterior surface contamination that could not be sufficiently cleaned prior to extraction, since the overall level of laboratory contamination was low.

- The frequency of sequence heteroplasmy was 11.4%, and both hot-spot and novel sites were observed.
MtDNA and hair

• About 93% of hairs provide mtDNA info¹
  – 1.0 cm of hair is typically sufficient
  – Hairs up to 30 years with no significant environmental damage still work
  – Rate of heteroplasmy is about 9-14%

• With telogen roots, hair success rate is independent of
  – cosmetic hair treatments; medulla structure; shaft length, diameter, and volume; and scalp origin.²

¹Melton, et al., JFS V50, N1, 2005
²Roberts and Calloway, JFS V52, N1, 2007