Forensic Hair Comparisons

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Specific questions

• **What is the state of the art?**
  – I hope this presentation demonstrates the state of the art

• **Where is research conducted?**
  – Little research is conducted in forensic hair examinations, except for mtDNA

• **Where is it published?**
  – When conducted, it is published in peer review journals
Basis of forensic hair microscopy

• Comparative biology, including medicine and physical anthropology, has a long history of microscopic identification and comparison dating back to the 18th century.
  – Comparison is the cornerstone of the majority of biology, both past and present.
• Microscopic techniques, combined with studied experience, provide for a discriminating means to examine and compare hair.
• Literature in physical anthropology and forensic science detailing the differences between peoples’ hair supports the credibility of the science
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
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?
Human head hair

This hair demonstrates a thin cuticle and clumpy pigment.
What area of the body is it from?

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

These carry the most information for microscopic comparisons
European ancestry head hair
African ancestry head hair
Asian ancestry head hair
European ancestry pubic hair
Pubic area hair
Determination of Racial Origin

- European ancestry “Caucasian”
- African ancestry “Negroid”
- Asian ancestry “Mongoloid”
European ancestry

- Shaft diameter *moderate* with minimal variation
- Pigment granules sparse to moderately dense with fairly *even distribution*
- *Oval* cross-sectional shape
European Ancestry Head hairs - cross-section
African ancestry

- Shaft diameter fine to moderate with considerable variation
- Pigment granules densely distributed and arranged in clumps
- Flattened cross-sectional shape
African ancestry head hairs - cross section
Asian ancestry

• Shaft diameter coarse, little or no variation
• Pigment granules densely distributed and arranged in large patches or streaks
• Prominent medulla (broad and continuous)
• Cuticle thick
• Round cross-sectional shape
Asian ancestry head hairs - cross section
Damage/disease/treatment
Damage

• Breaking
• Burning
• Putrefied roots
• Insect marks
• Cutting
• Crushing
Putrefied roots
Artificial Treatment

• Bleaching
  - solar
  - chemical

• Dyeing
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
Suitable known sample

- Must be representative
- Sample all areas of the head
- Minimum of 25-50 hairs
- Combed and plucked hairs
- Include any hair weaves, braids, etc.
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
Tip

- Natural
- Cut
- Broken
- Abraded, split
CUT TIP
Straight edged implement.
SPLIT ENDS

Longitudinally split shaft.
RED HAIR

Note the central concentration of pigment. This patterning is most prominent in red hair.
Cuticle

- Color
- Thickness
- Damage
THICK CUTICLE
This hair displays several of the characteristics associated with individuals of Negroid ancestry.

*Diameter variation
Clumpy Pigment*
Scales

- Size
- Protrusion
- Looping
- Damage
LOOPECUTICLE

Damaged hair resulting from treatment or weathering may demonstrate scales in which the distal margins are lifted up or frayed.

Looped cuticles occur when the distal margins affix themselves to the cuticle forming a loop.
This hair demonstrates a thin cuticle and clumpy pigment.
Cortex

- Cortical cells - spindle shaped
- Visible or not
Pigment

• Arrangement
• Distribution
• Density
• Size of granules
• Gapping
PIGMENT DISTRIBUTION

Even pigment distribution is characteristic of individuals of Caucasian ancestry.
CHY PIGMENT

ules form patchy
us patterning is
antly associated with
golid race.
Medulla

- Presence or absence
- Thickness
- Fragmentary, discontinuous, continuous
- Clear or opaque
- Cellular or smooth
Ensembles of Class Traits

1. Thornton, JFS, 1986
## Ensemble of Class Traits

<table>
<thead>
<tr>
<th>Root</th>
<th>abundant fusi telogen anagen decomp stretched follicular tag cut broken pointed round</th>
</tr>
</thead>
<tbody>
<tr>
<td>Width</td>
<td>coarse fine variation along shaft variation w/in sample</td>
</tr>
<tr>
<td>Cuticle</td>
<td>thickness variation in thickness clarity color</td>
</tr>
<tr>
<td>Scales</td>
<td>protrusion slight medium great</td>
</tr>
<tr>
<td>Tip</td>
<td>length short medium long thickness thin medium thick fluctuation</td>
</tr>
<tr>
<td>Medulla</td>
<td>absent</td>
</tr>
<tr>
<td>Cortex</td>
<td>cells prominent cells obscured size of granules shape of granules density local distribution</td>
</tr>
<tr>
<td>Pigment</td>
<td>patchy streaky chaining</td>
</tr>
<tr>
<td>distribution w/in shaft gapping</td>
<td></td>
</tr>
<tr>
<td>Width</td>
<td>shallow short medium deep long</td>
</tr>
<tr>
<td>Width</td>
<td>pigment in cuticle</td>
</tr>
<tr>
<td>Cosmetic</td>
<td>bleached dyed length of time since treatment</td>
</tr>
<tr>
<td>Special</td>
<td>cracked cuticle ovoid bodies double medulla diseases vermin</td>
</tr>
</tbody>
</table>
Inclusion

Exclusion
Conclusions: Inclusion

• 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.
Conclusions: Inconclusive

• 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.
Conclusions: Exclusion

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

• About 93% of hairs provide mtDNA info\(^1\)
  – 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.\(^2\)

\(^1\)Melton, et al., *JFS* V50, N1, 2005
\(^2\)Roberts and Calloway, *JFS* V52, N1, 2007
Reliability and reproducibility

- Several clinical studies and research projects with published and peer reviewed reports have demonstrated that given a limited number of questioned and known hair samples, correct inclusions and exclusions are the rule rather than the exception

- Bisbing and Wolner, 1984; Lamb and Tucker, 1994; Gaudette, 1976; Gaudette and Keeping, 1974; Strauss, 1983; Wickenheiser and Hepworth, 1990; Houck and Budowle, 2002
# Clinical studies

<table>
<thead>
<tr>
<th>Study</th>
<th>Year</th>
<th>Results</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gaudette (h)</td>
<td>1974</td>
<td>9 in 366,630 pairs (1 in 40,737 pairs)</td>
</tr>
<tr>
<td>Strauss (h)</td>
<td>1983</td>
<td>0 in 4,900 pairs</td>
</tr>
<tr>
<td>Wickenheiser (h)</td>
<td>1990</td>
<td>7 in 431,985 pairs (1 in 61,712 pairs)</td>
</tr>
<tr>
<td>Gaudette (p)</td>
<td>1976</td>
<td>16 in 101,368 pairs (1 in 6,336 pairs)</td>
</tr>
<tr>
<td>Proficiency Tests</td>
<td>1995</td>
<td>&lt;8% error rate</td>
</tr>
<tr>
<td>Houck and Budowle</td>
<td>2002</td>
<td>Of 127 cases, 9 excluded by mtDNA</td>
</tr>
</tbody>
</table>
Houck and Budowle, 2002

<table>
<thead>
<tr>
<th>Microscopic Results</th>
<th>Association</th>
<th>Inconclusive</th>
<th>Exclusion</th>
<th>Insufficient</th>
</tr>
</thead>
<tbody>
<tr>
<td>Association</td>
<td>69</td>
<td>1</td>
<td>9</td>
<td>1</td>
</tr>
<tr>
<td>Inconclusive</td>
<td>15</td>
<td>1</td>
<td>20</td>
<td>1</td>
</tr>
<tr>
<td>Exclusion</td>
<td>0</td>
<td>1</td>
<td>17</td>
<td>1</td>
</tr>
<tr>
<td>Insufficient</td>
<td>13</td>
<td>0</td>
<td>18</td>
<td>3</td>
</tr>
</tbody>
</table>

N = 170 comparisons
Specificity/selectivity

• Blood-typing indicates that a crime scene stain and the suspect were both Type A+ blood
  – Later excluded by DNA
  – But the blood typing was correct, in so far as it goes
• This is analogous with microscopical hair comparisons
  – Just because the mtDNA does not “match” does not mean the questioned hair does not exhibit the same characteristics as the known sample
Specific questions

• Where are new developments coming from?
• What are the major problems in the scientific foundation or methods and in the practice?
  – Training and quality
  – Support from lab directors, attorneys, and police
  – Adequate resources: **Money**.
• What research questions can be answered?
  – Specificity/selectivity; animal hairs; genetic component of traits;