Forensic Hair Comparisons

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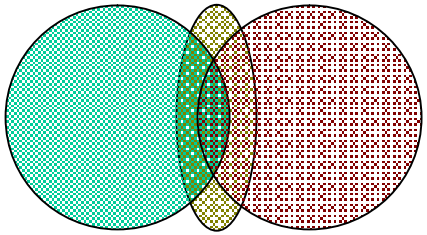
Specific questions

- **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

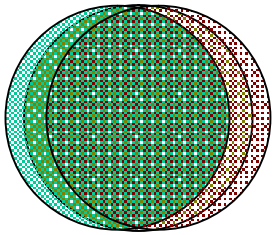
Basis of forensic hair microscopy

- 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



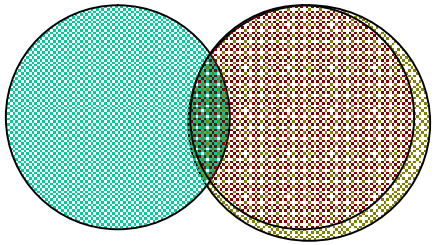
Victim and **Criminal** only interact at a **Crime Scene** unfamiliar to both

Ex. Sexual assault in an alley



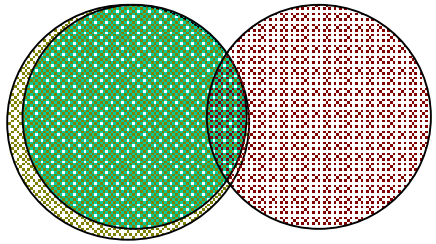
Victim and **Criminal** interact at a **Crime Scene** familiar to both

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*



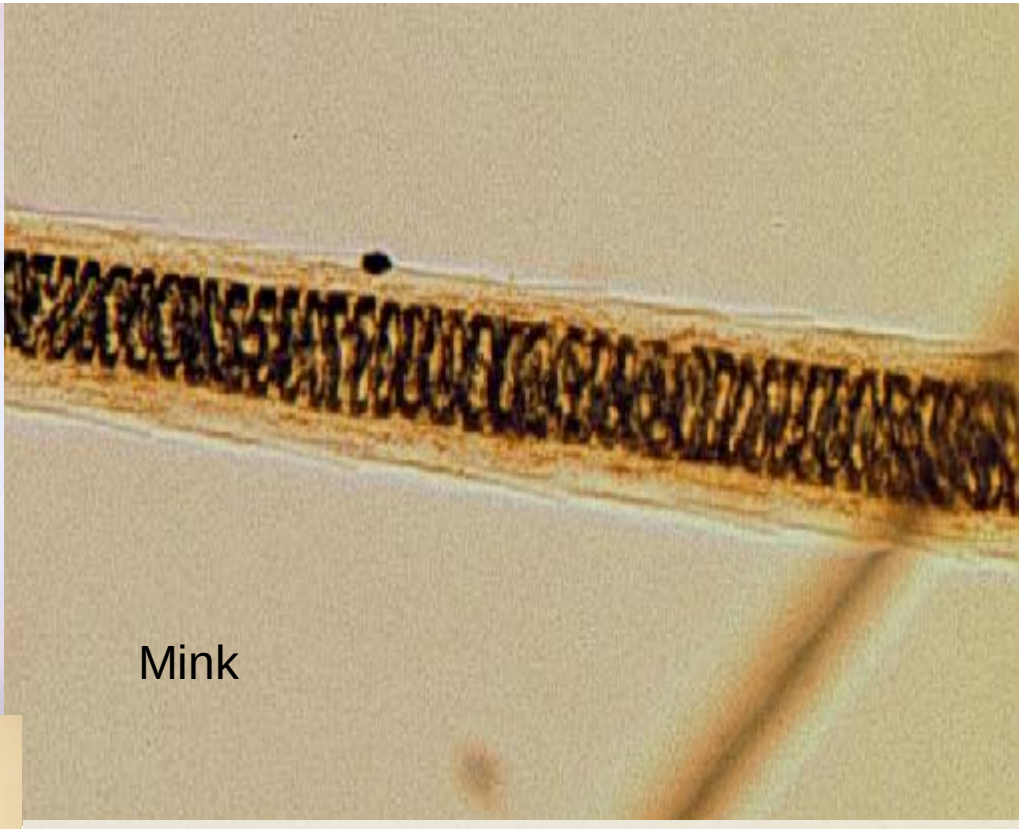
Victim and **Criminal** interact at a **Crime Scene** familiar only to the **Victim**

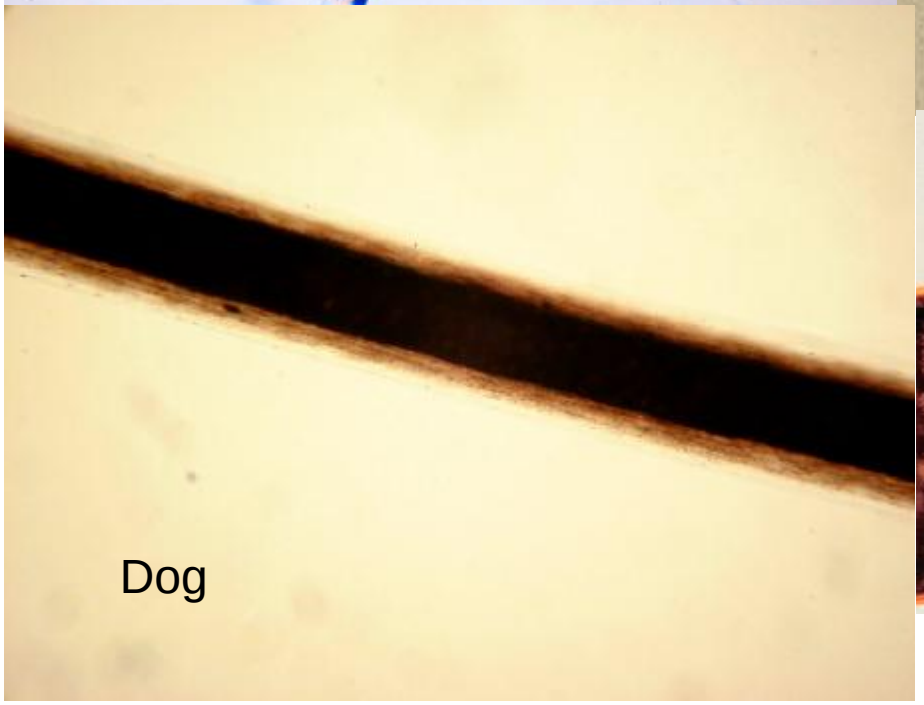
Ex. Home invasion

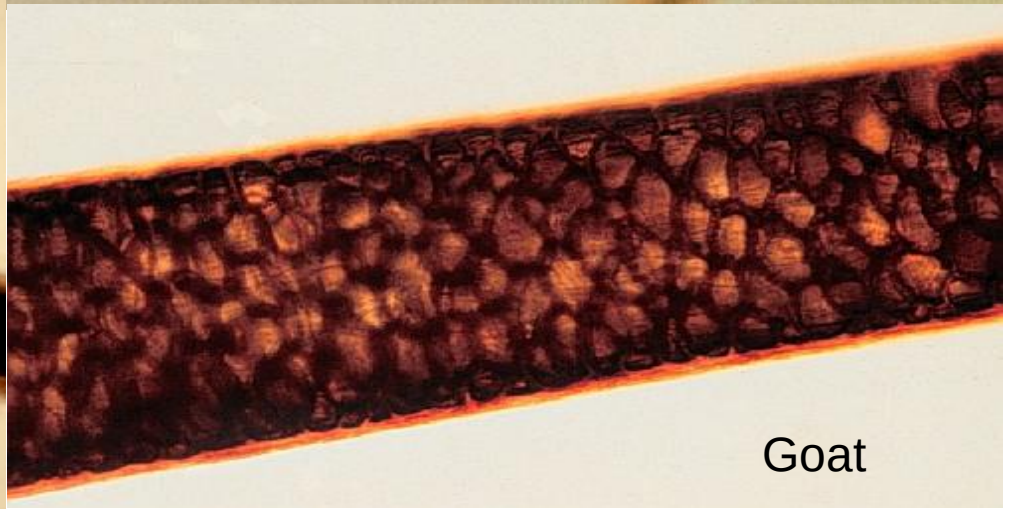
What can be determined?

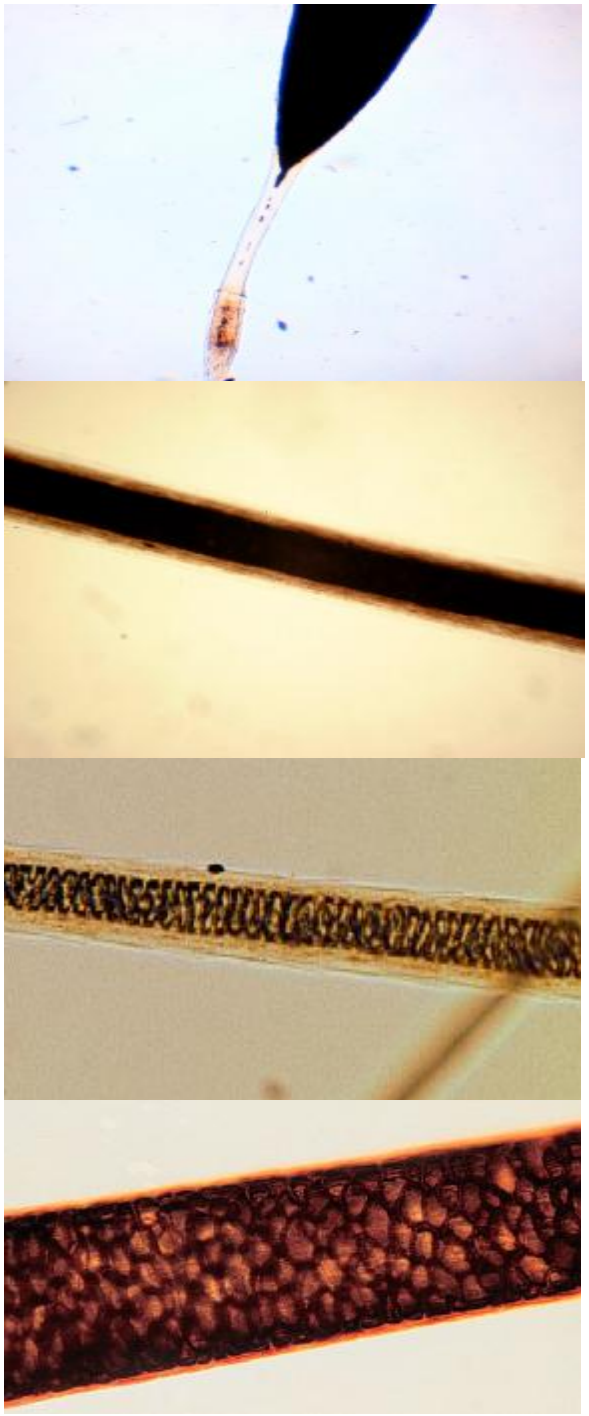
- **Is it a hair?**
- **Is it human?**
- **What area of the body is it from?**
- **What is the person's ancestry?**
- **Is there damage, disease, treatment?**
- **Is it suitable for comparison?**


Deer

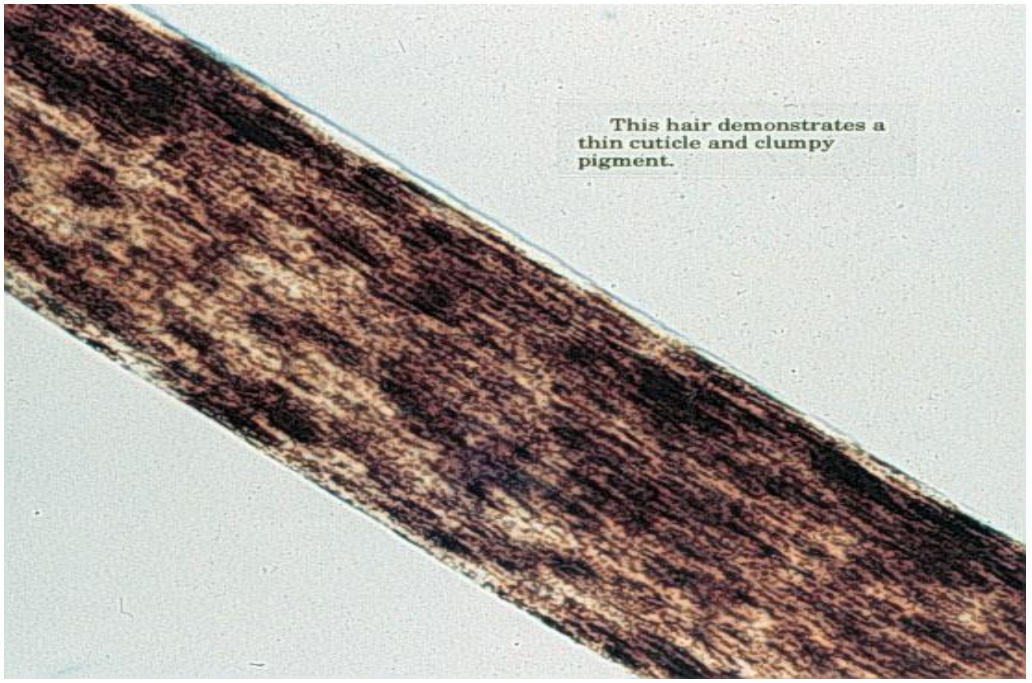

Mink


Dog


Goat

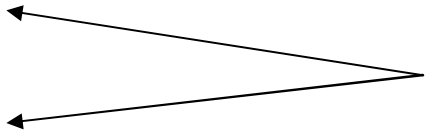


Human head hair

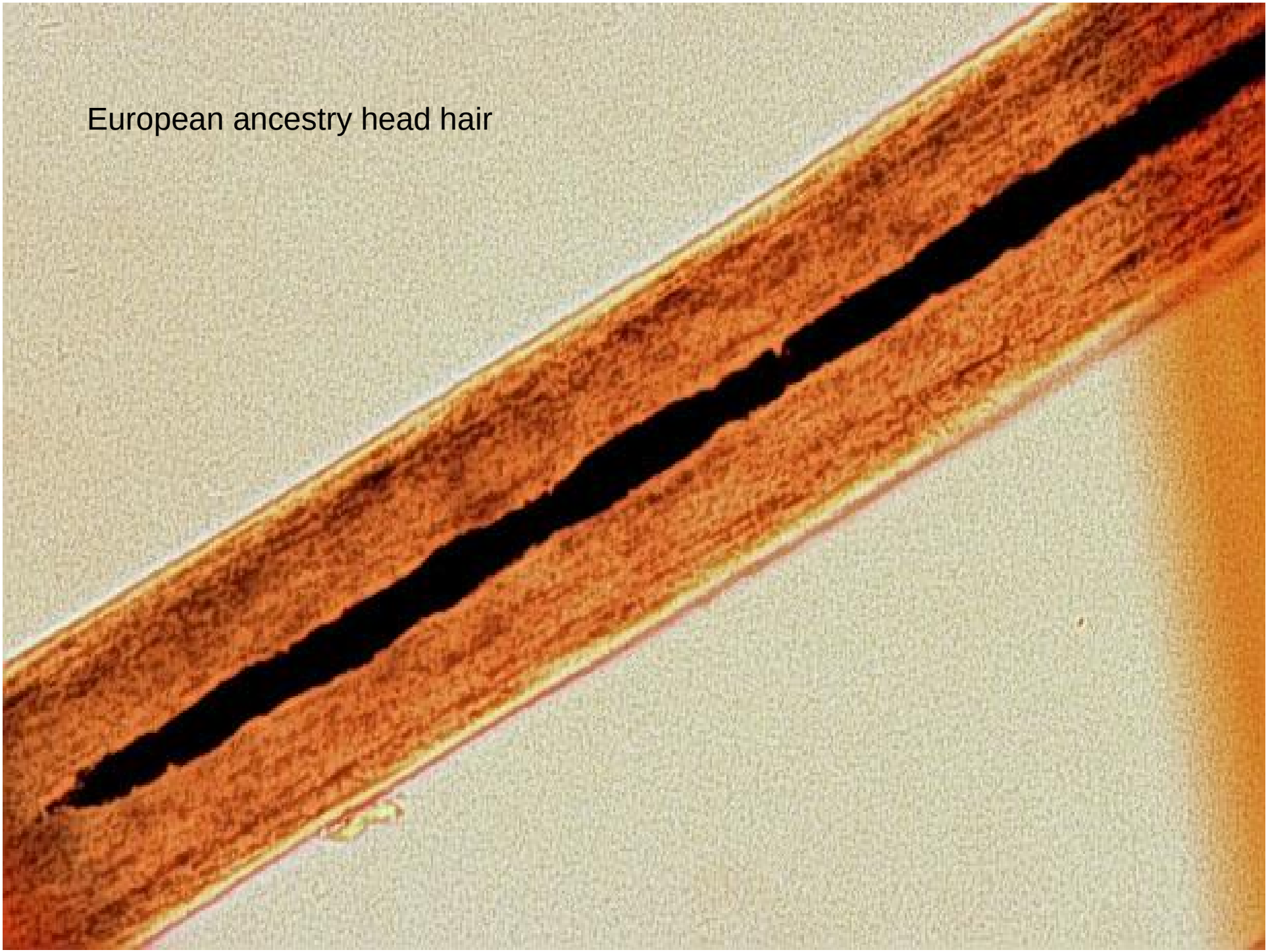


What area of the body is it from?

- 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

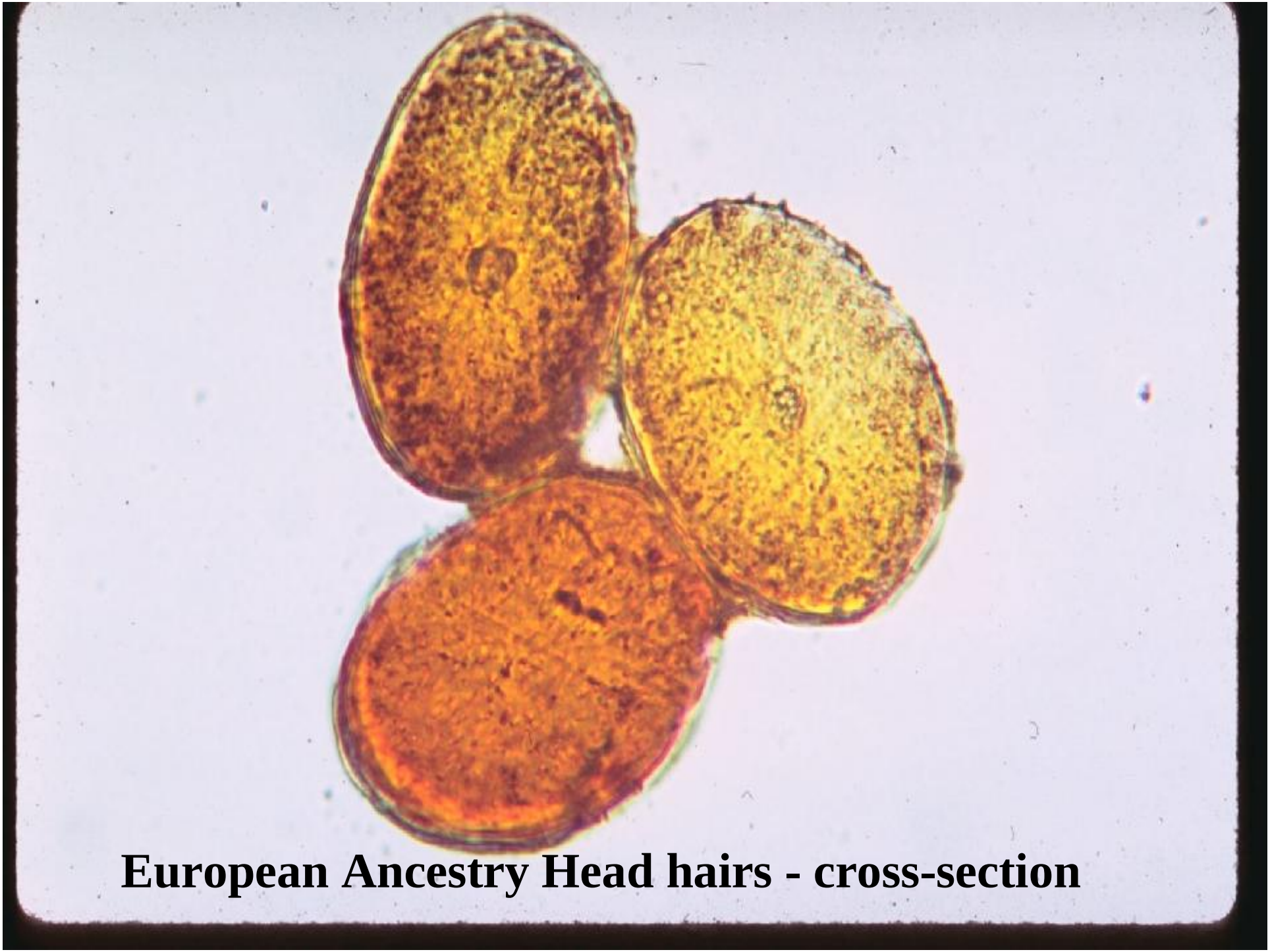

Pubic area hair

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

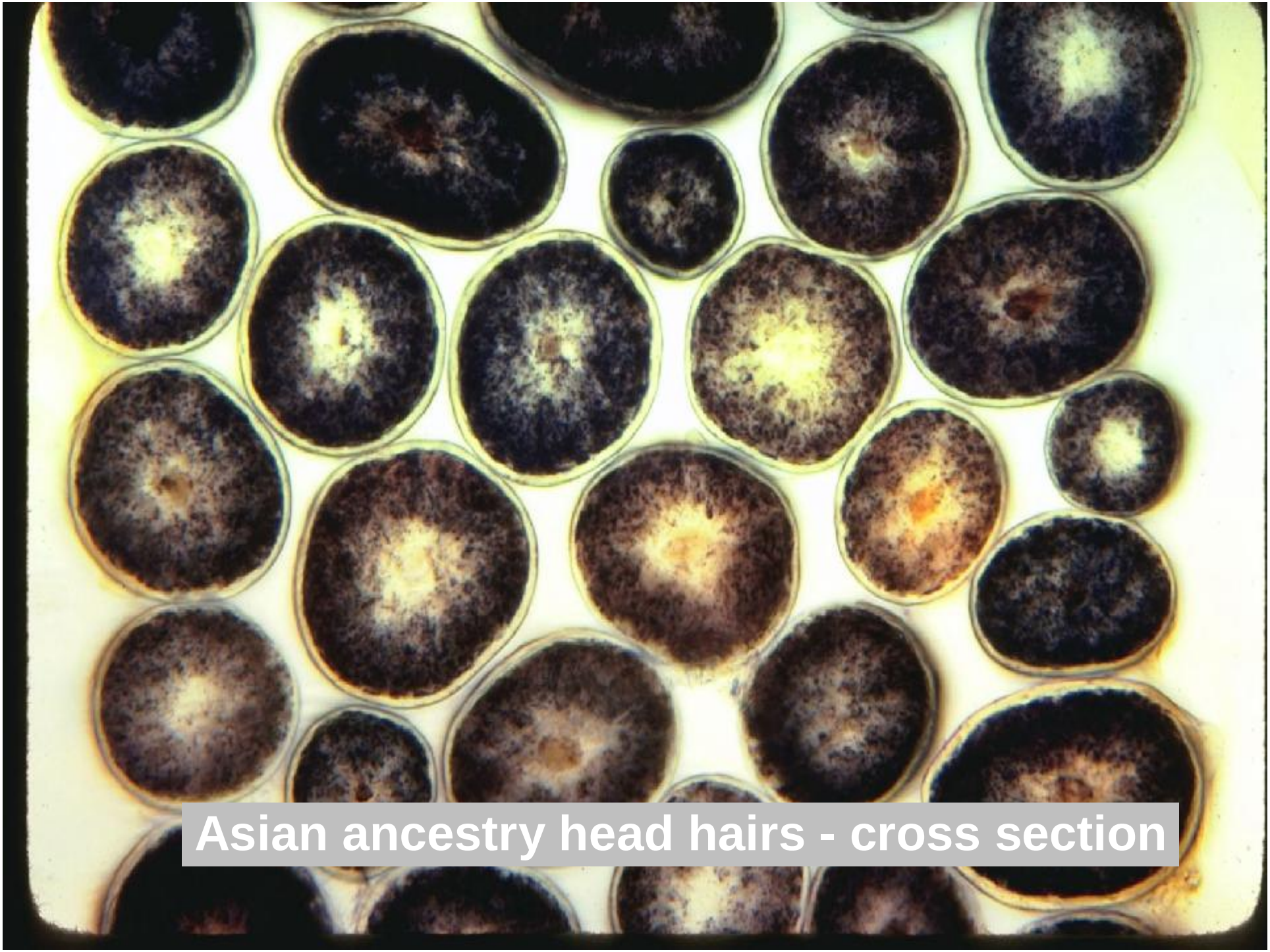
African ancestry

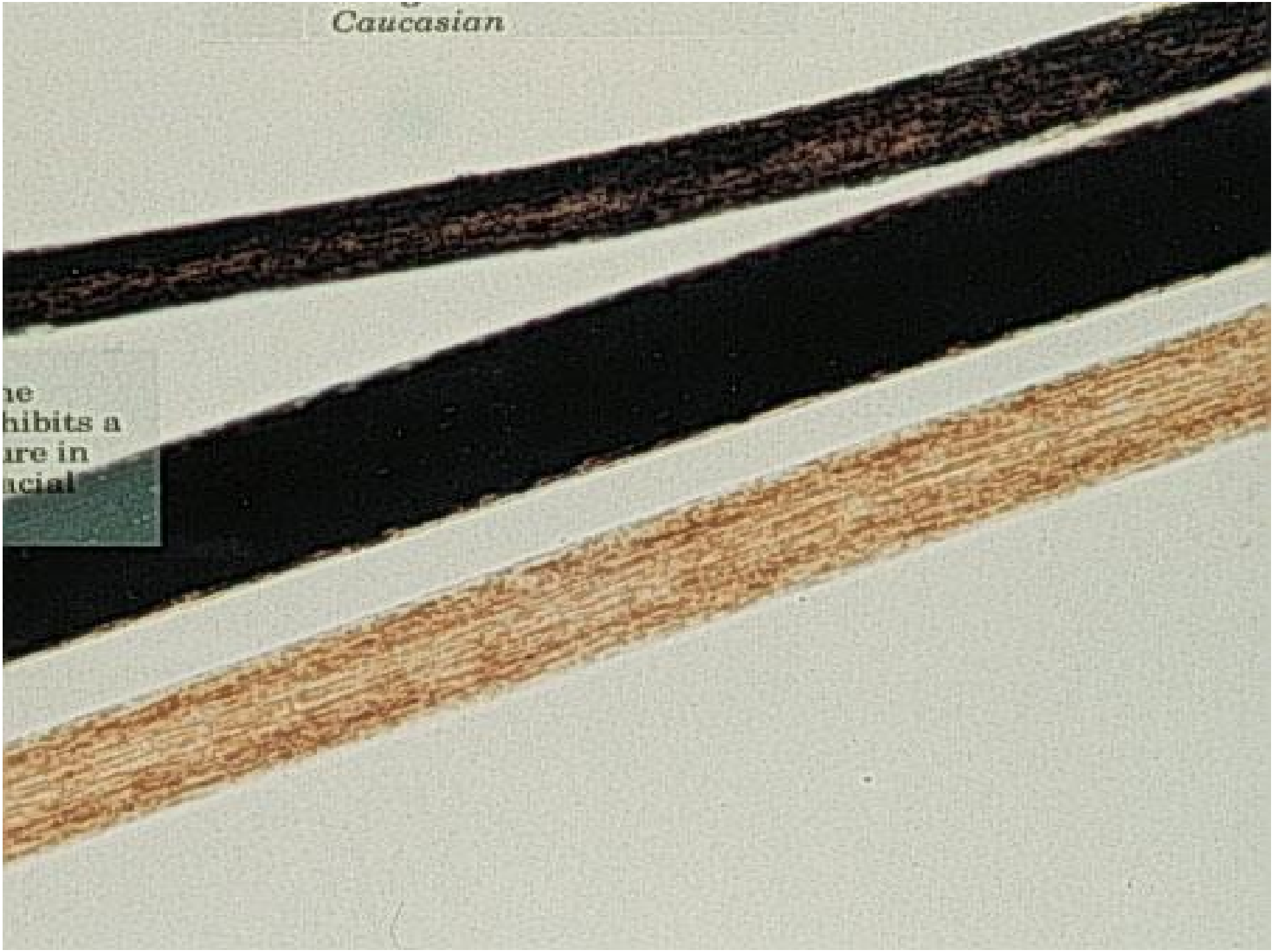
- **Shaft diameter fine to moderate with considerable variation**
- **Pigment granules densely distributed and arranged in clumps**
- **Flattened cross-sectional shape**


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


Caucasian
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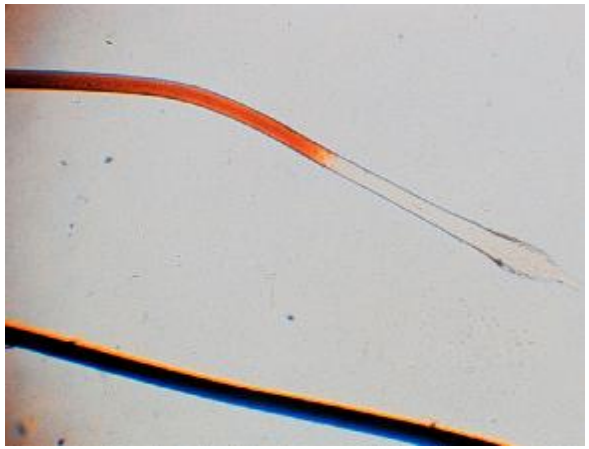
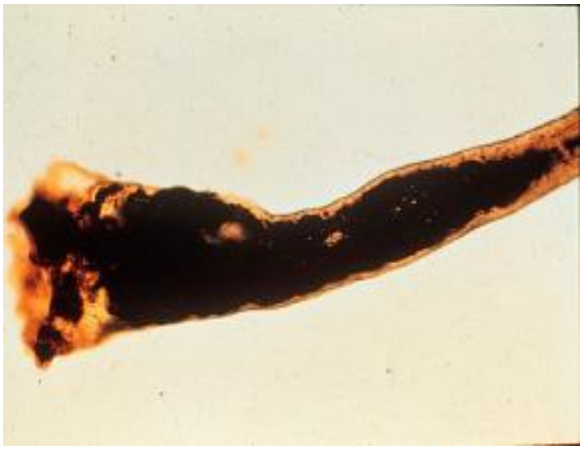
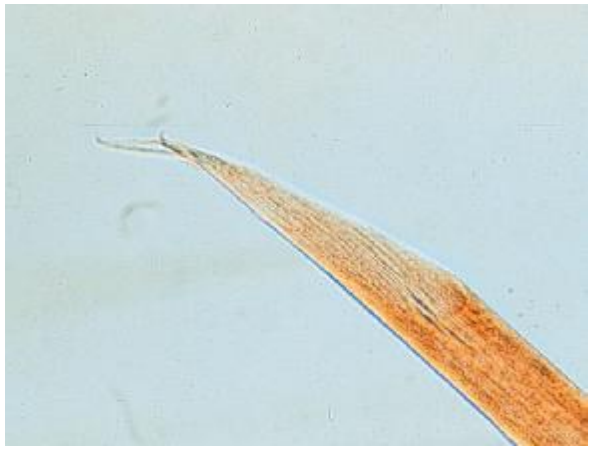
Damage/disease/treament



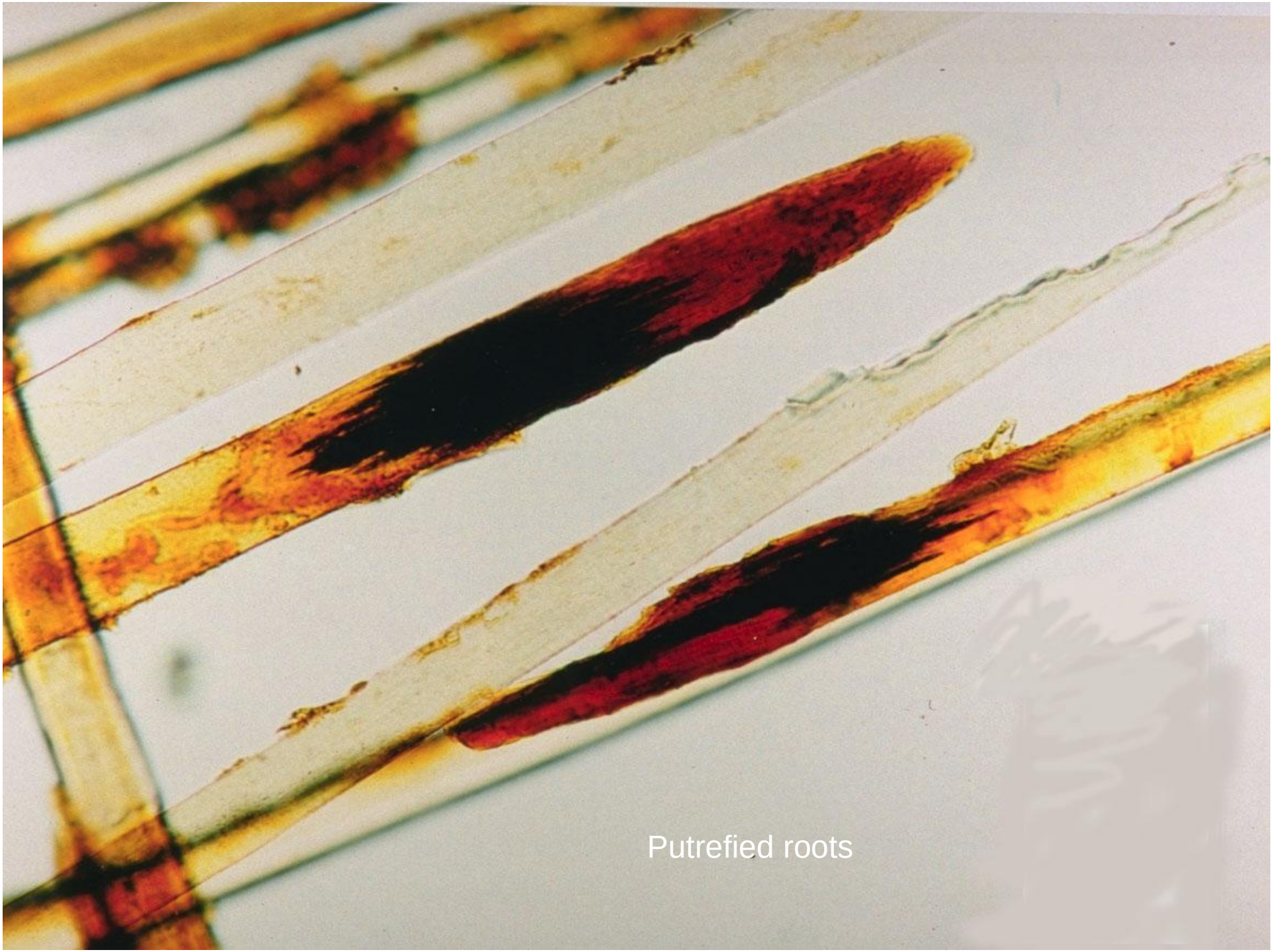




Damage

- **Breaking**
- **Burning**
- **Putrefied roots**
- **Insect marks**
- **Cutting**
- **Crushing**

Insect chewing


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

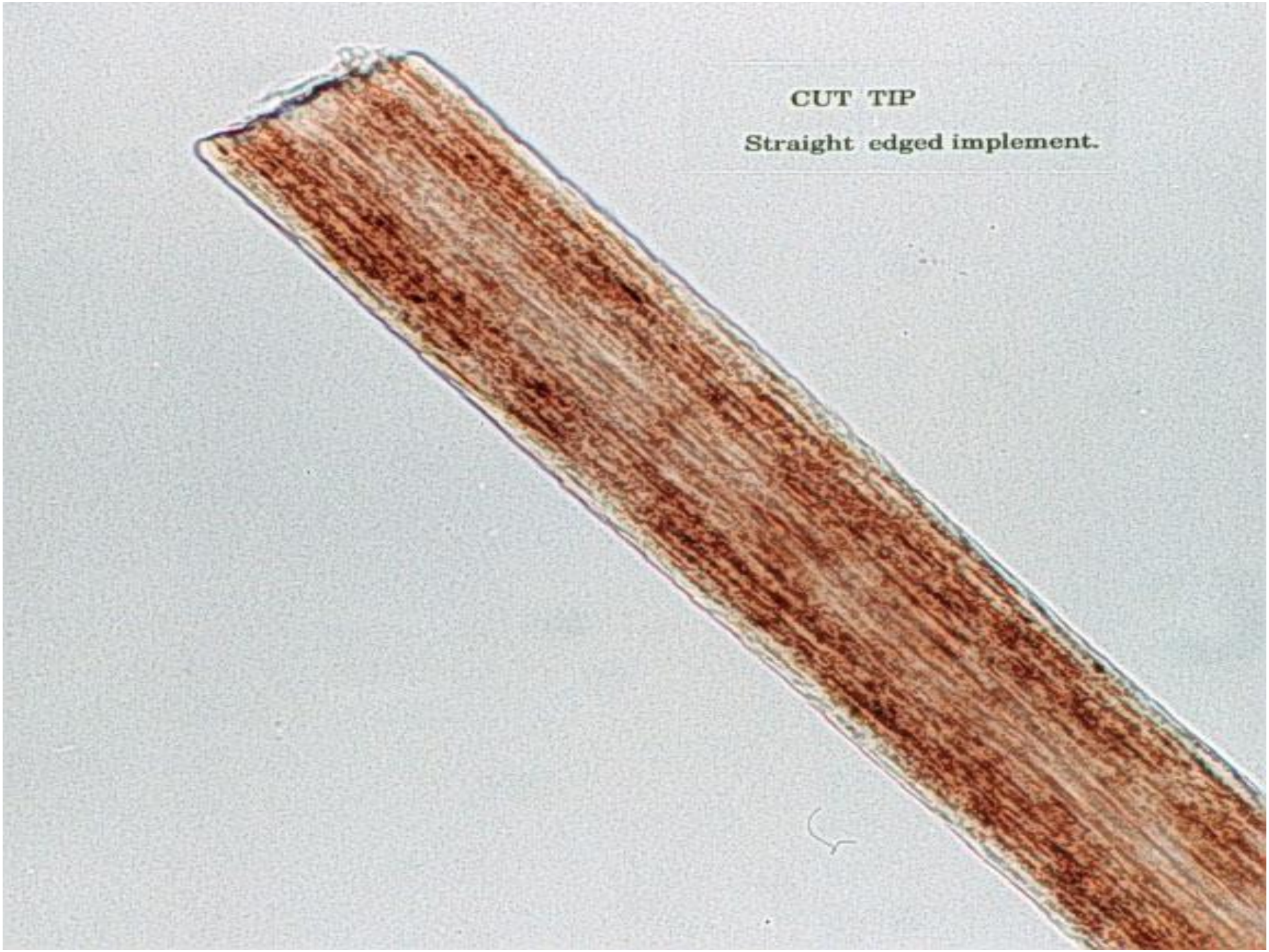
- **Must be representative**
- **Sample all areas of the head**
- **Minimum of 25-50 hairs**
- **Combed and plucked hairs**
- **Include any hair weaves, braids, etc.**

Comparison process

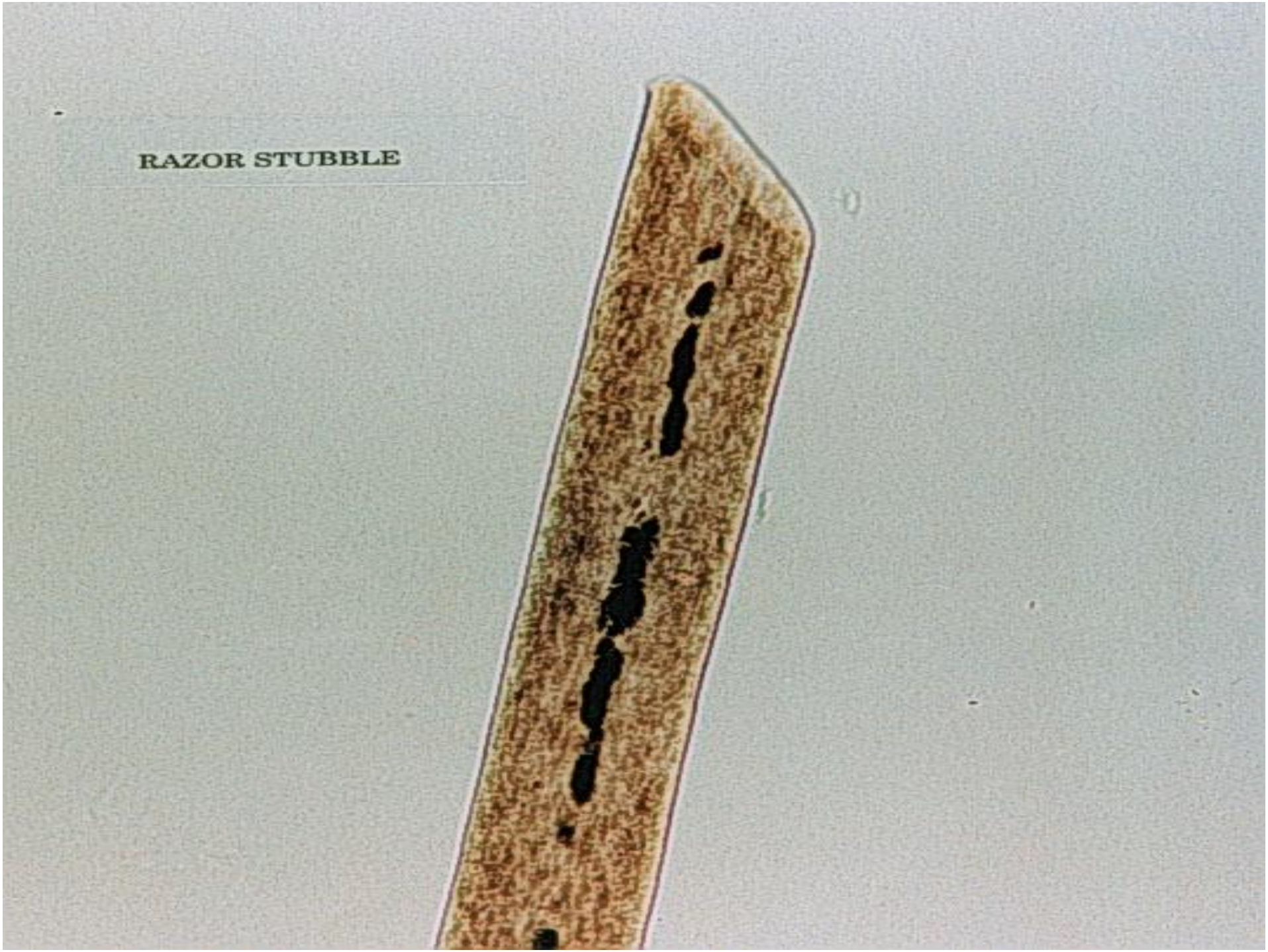
- **Uses a comparison microscope**
  - Two microscopes optically joined
  - Split-screen view
- **Two samples side-by-side simultaneously**
- **Use all characteristics available**
- **Questioned hair must fall within variation established by the Known sample**

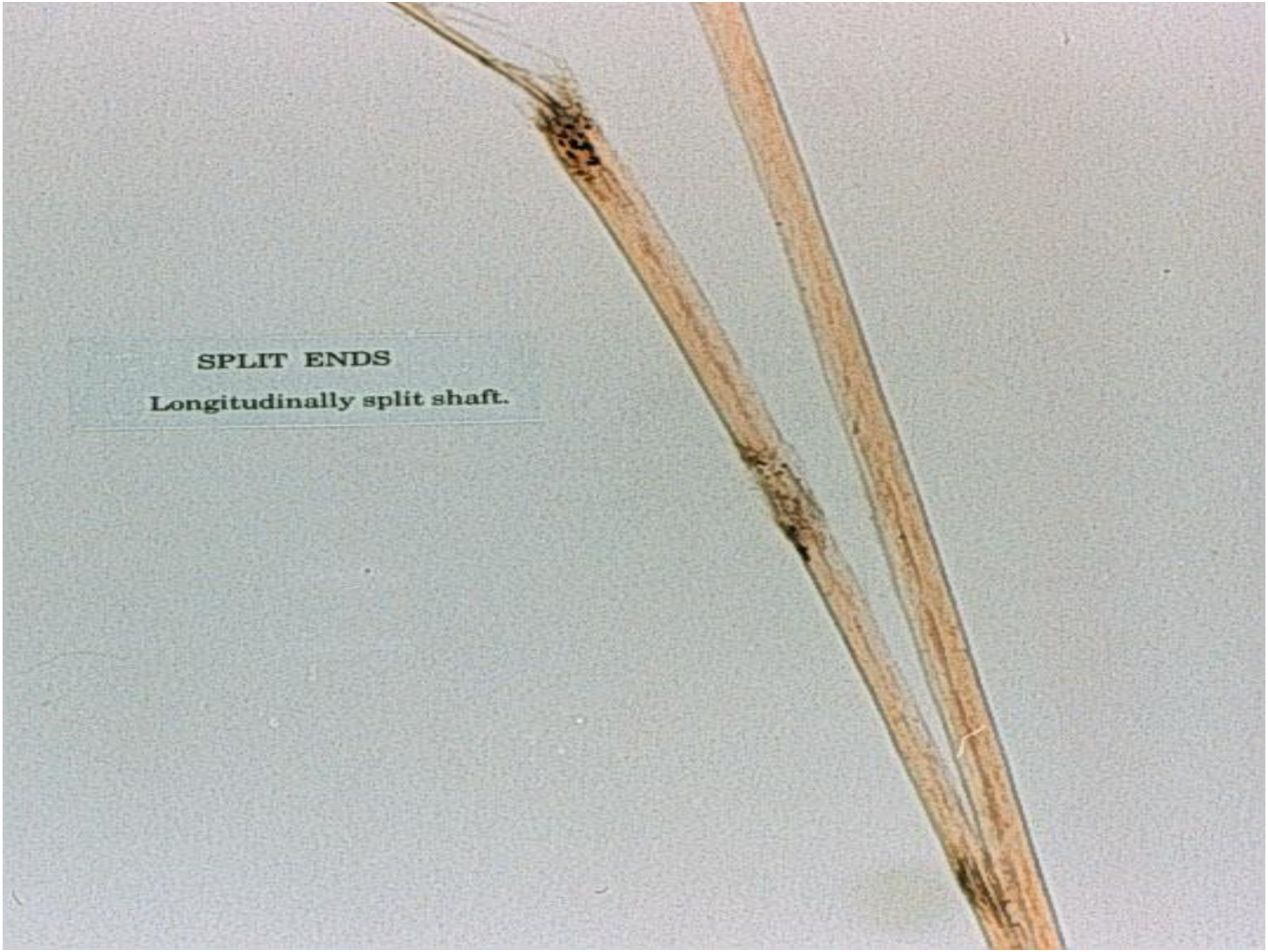
Tip

- **Natural**
- **Cut**
- **Broken**
- **Abraded, split**


CUT TIP
Straight edged implement.

RAZOR STUBBLE

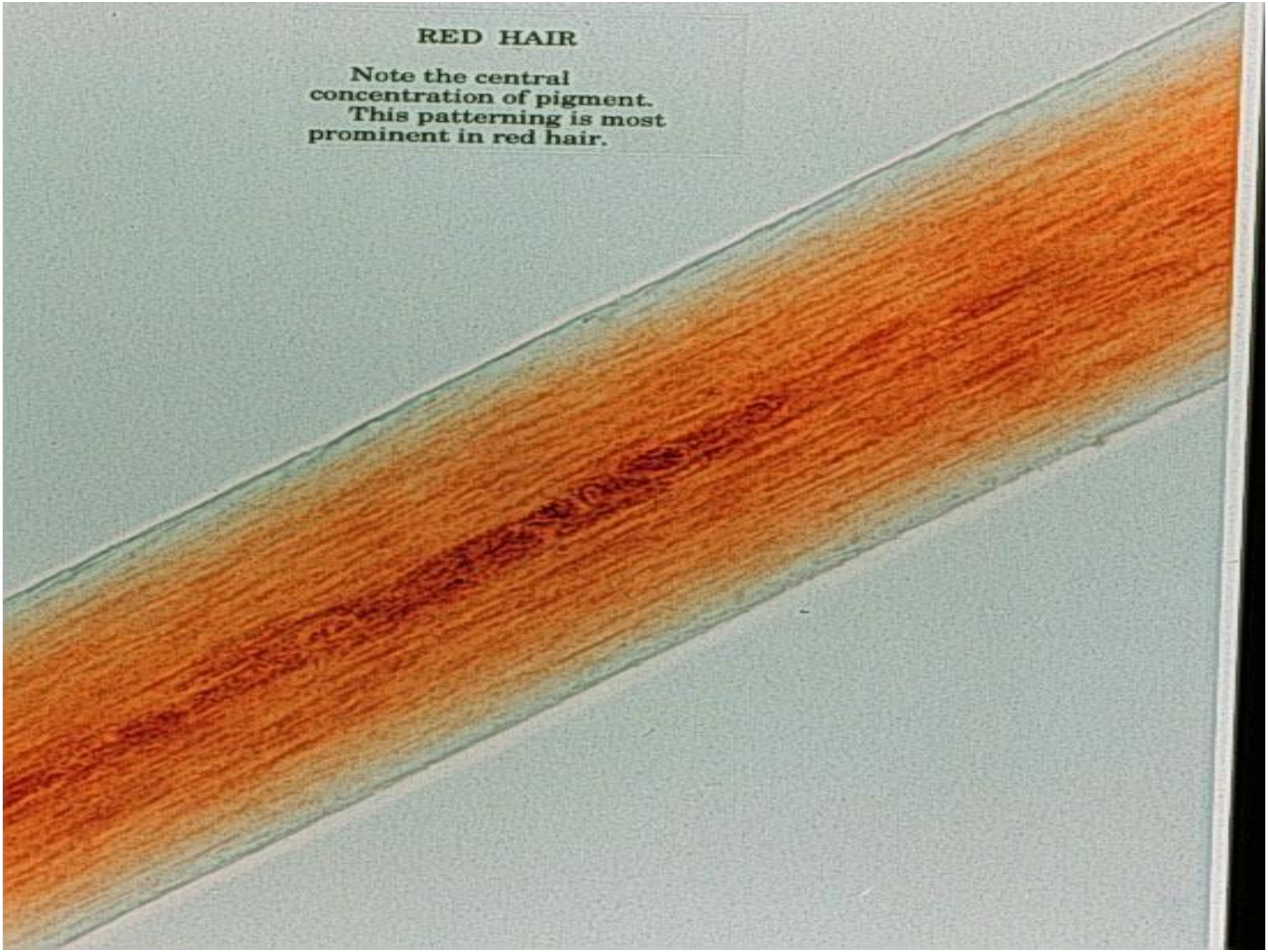




SPLIT ENDS

Longitudinally split shaft.

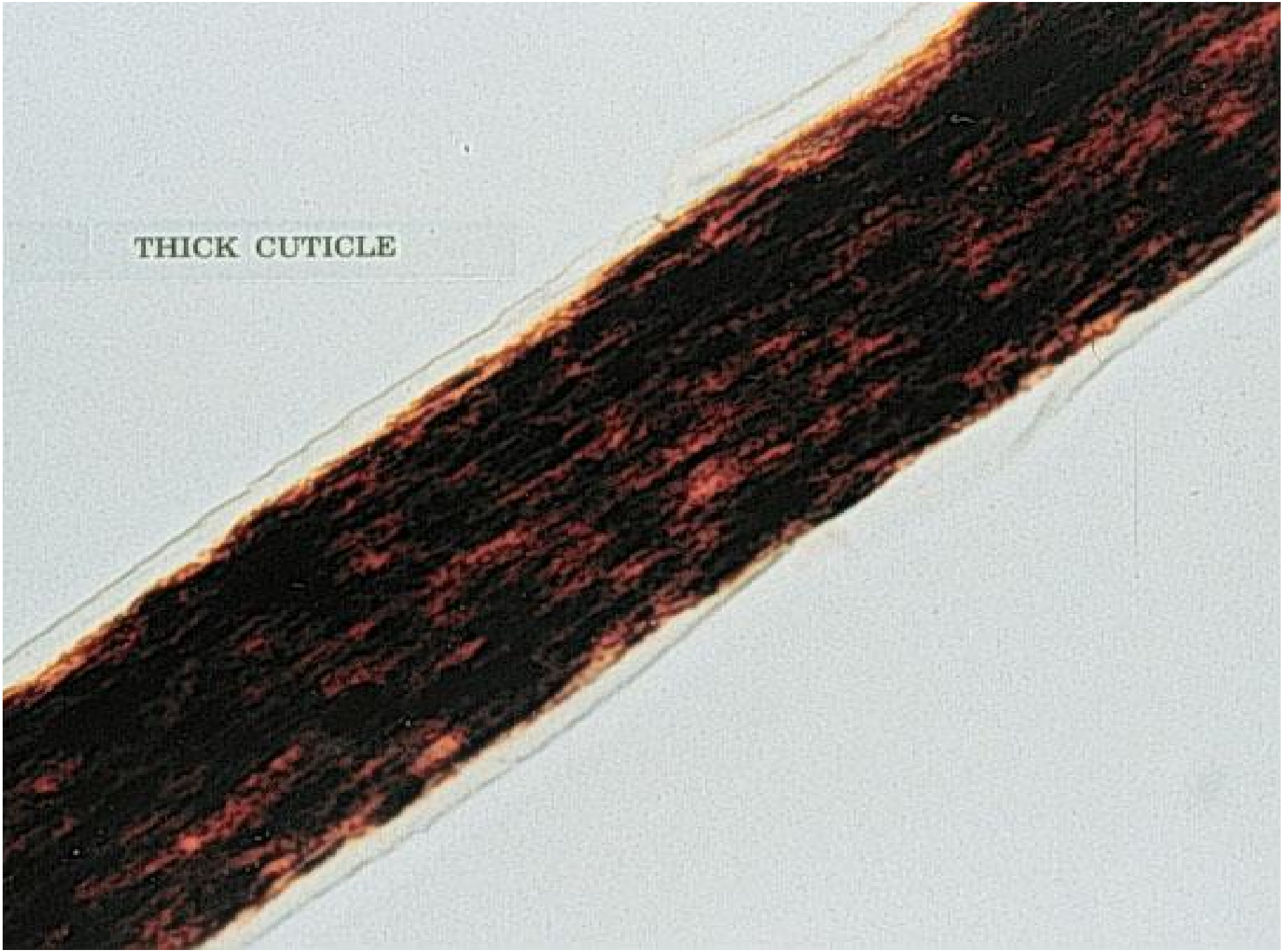
BLOND HAIR


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

BLACK HAIR

Cuticle

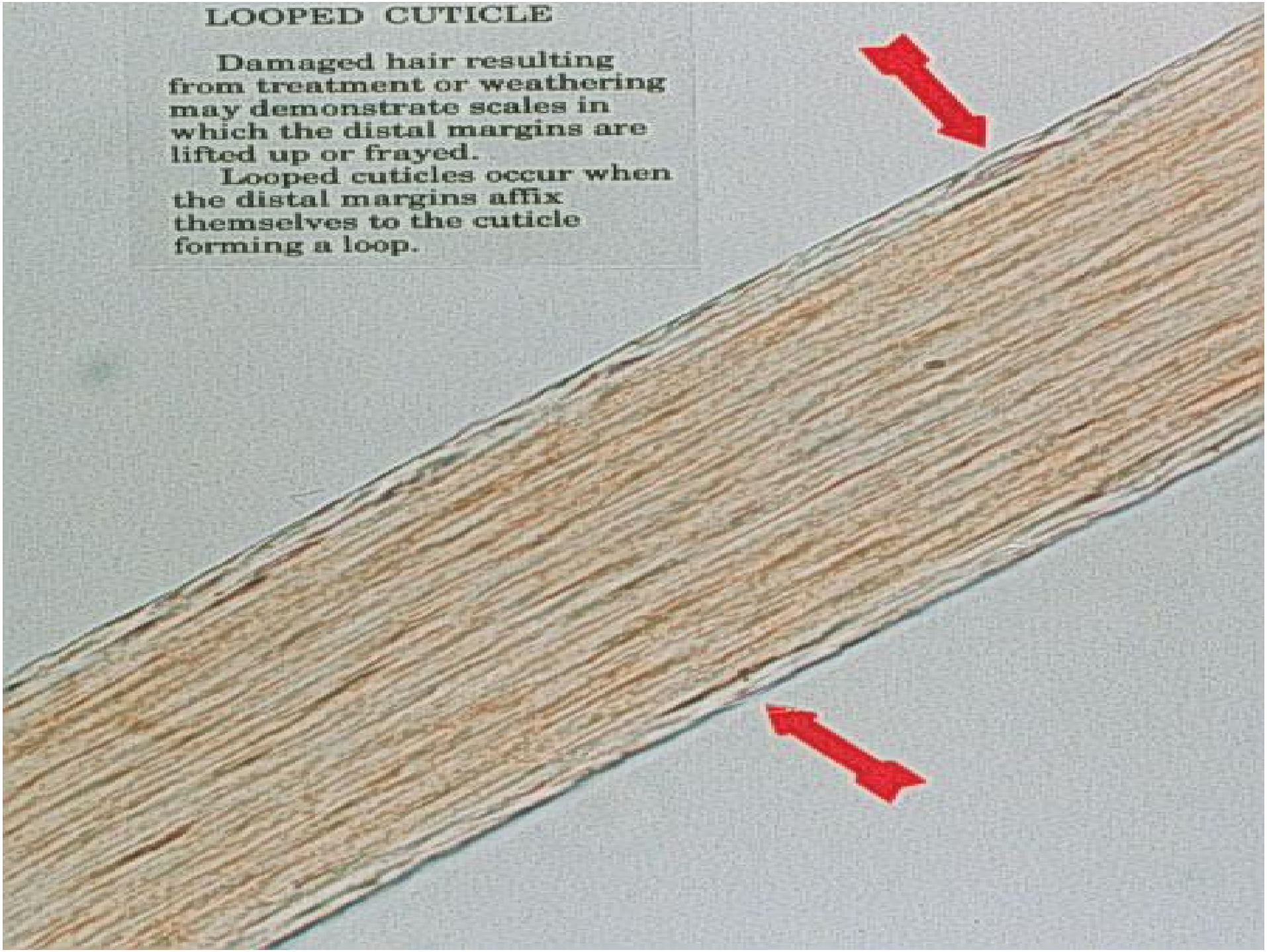
- **Color**
- **Thickness**
- **Damage**


THICK CUTICLE


This hair displays several of the characteristics associated with individuals of *Negroid* ancestry.
Diameter variation
Clumpy Pigment

Scales

- Size
- Protrusion
- Looping
- Damage


LOOPED CUTICLE
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.

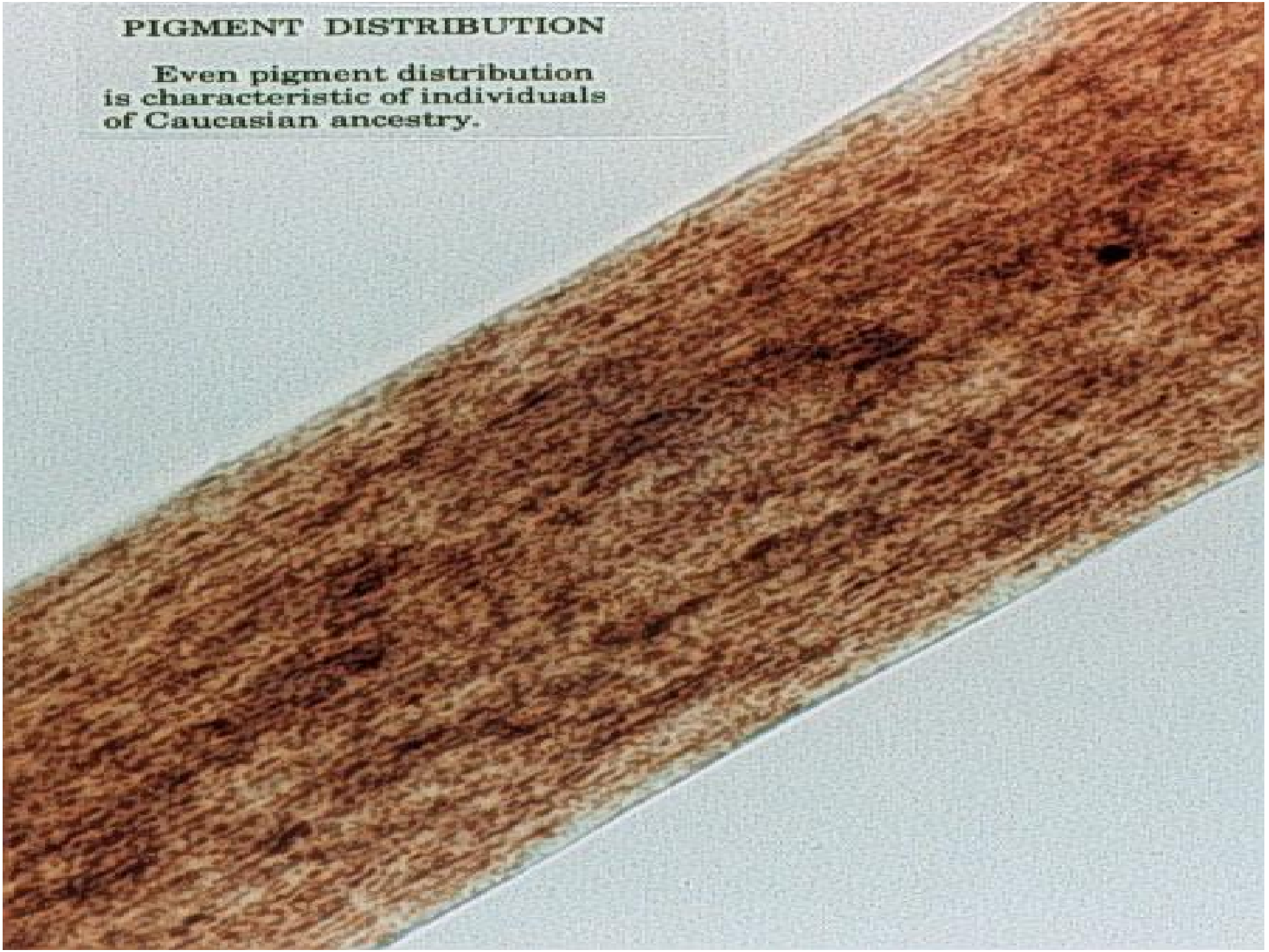
This hair demonstrates a thin cuticle and clumpy pigment.

Cortex

- **Cortical cells - spindle shaped**
- **Visible or not**

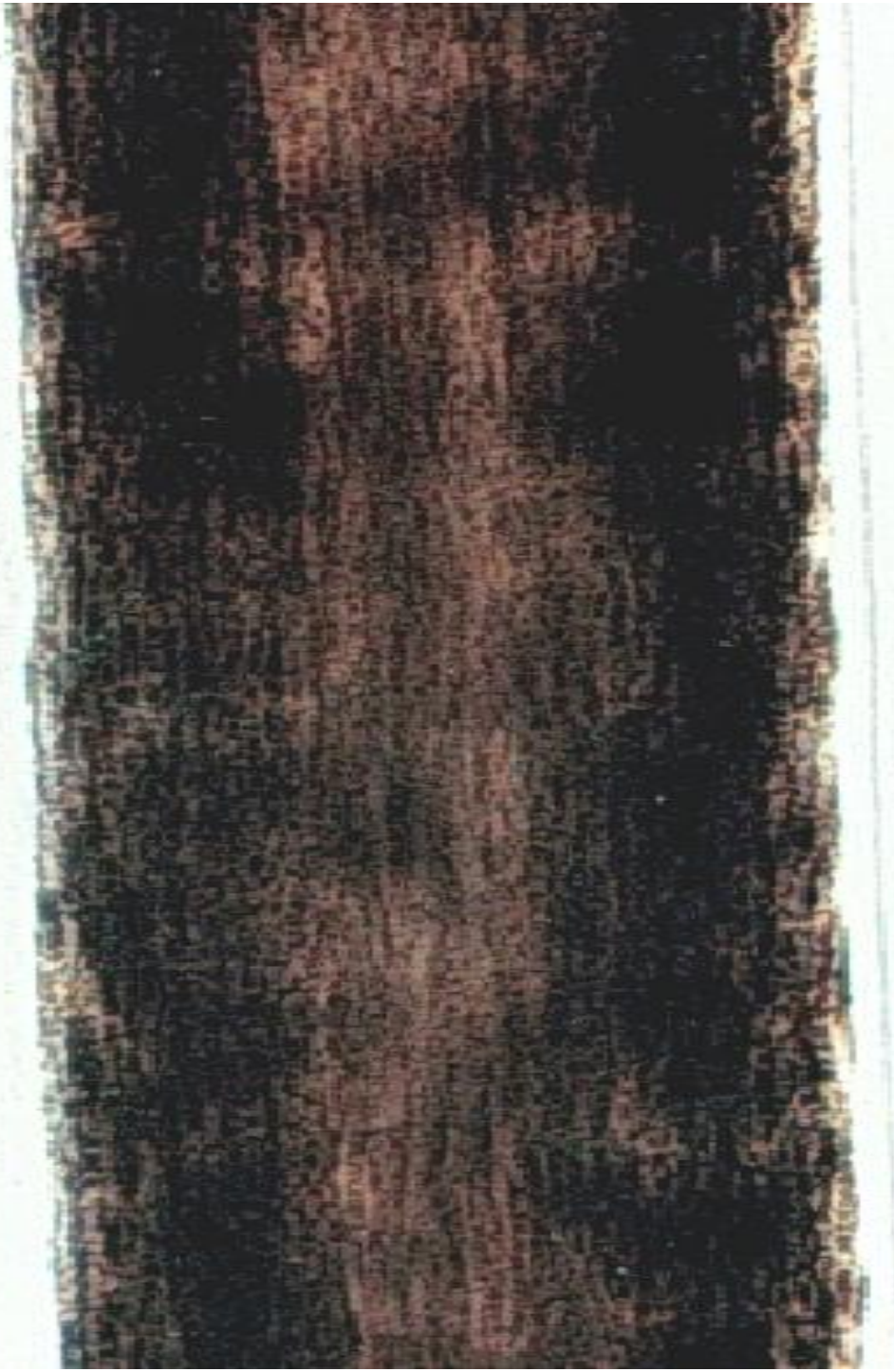
Pigment

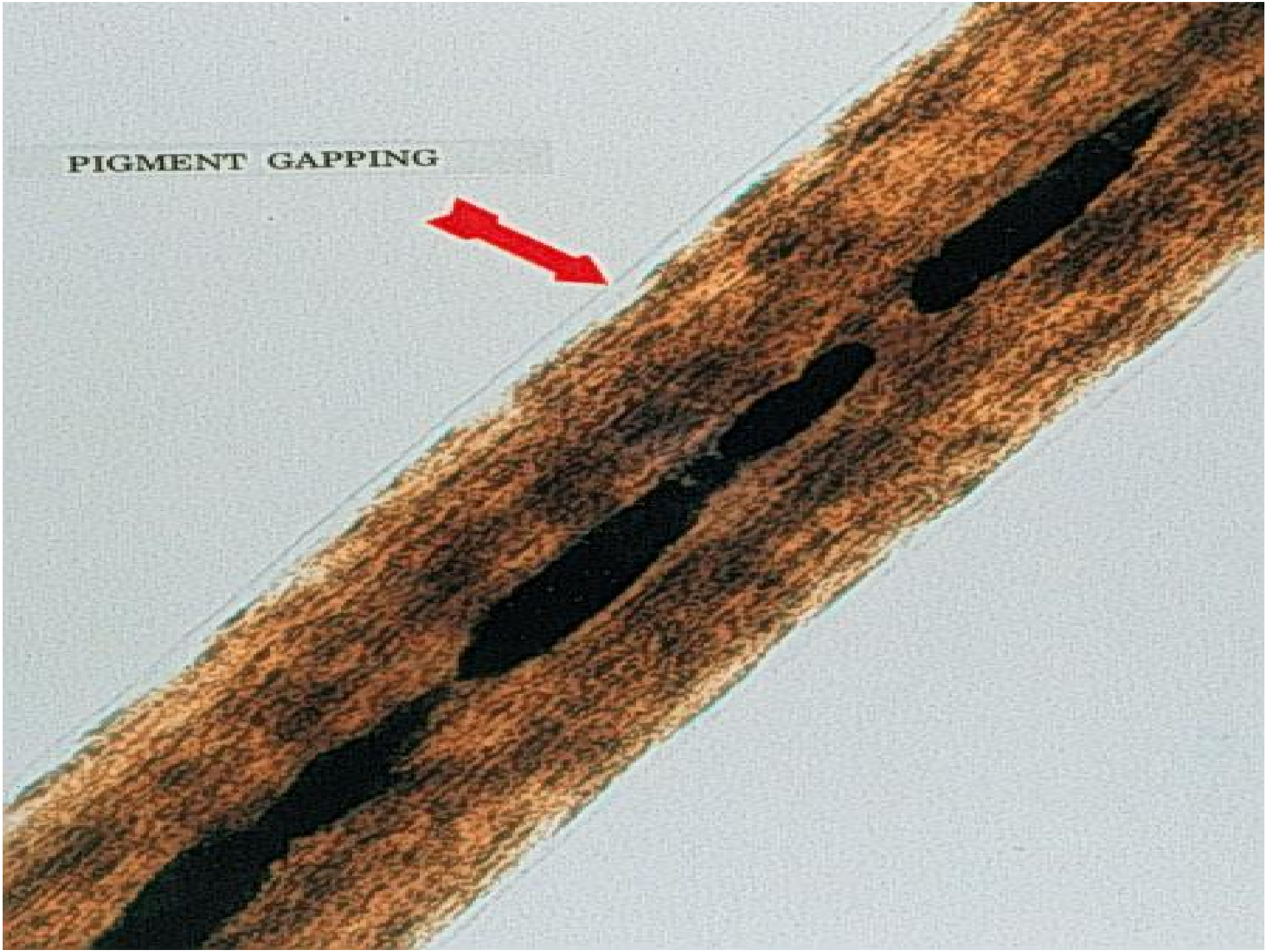
- Arrangement
- Distribution
- Density
- Size of granules
- Gapping


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

CHY PIGMENT

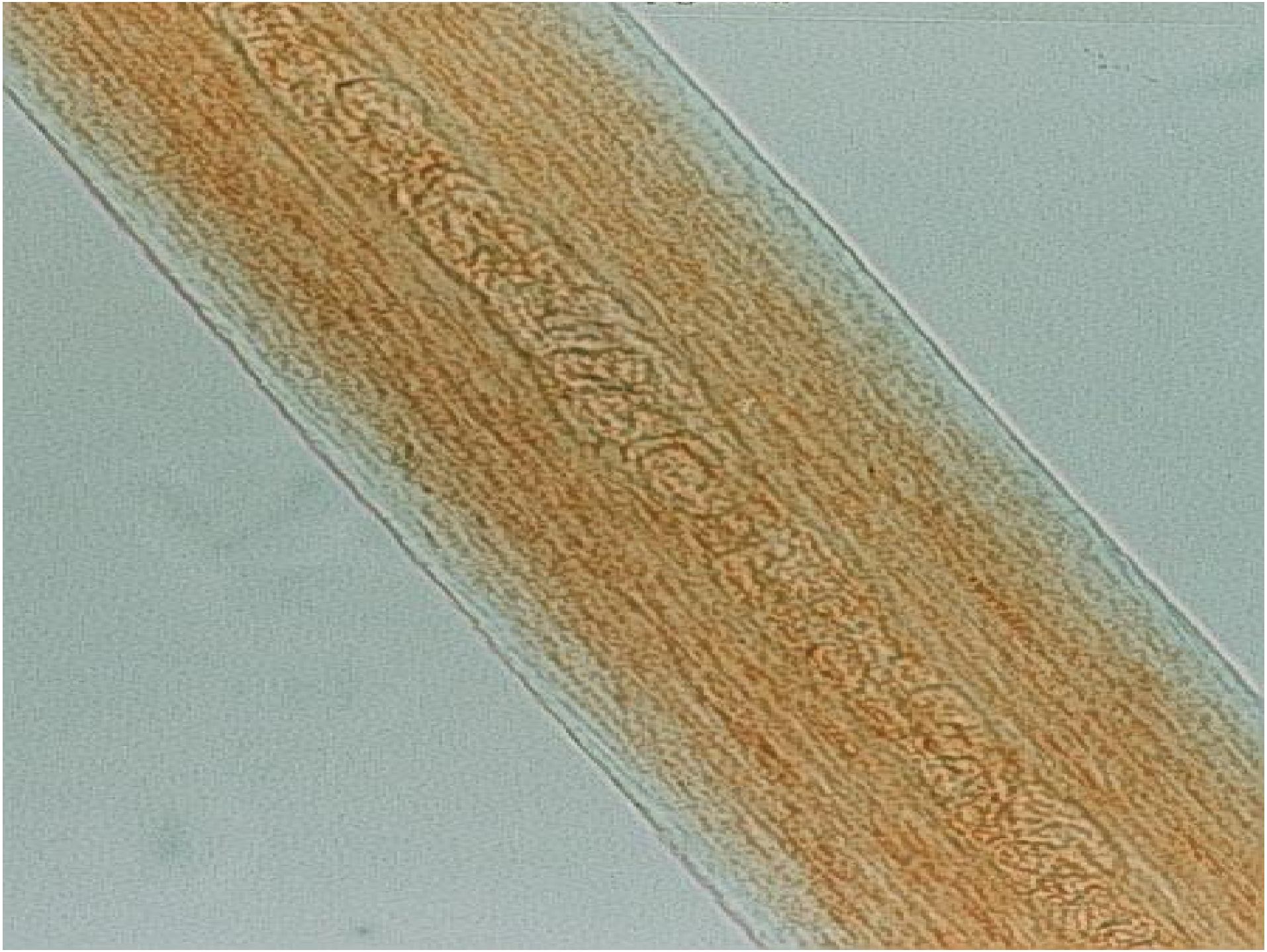
ules form patchy
is patterning is
nantly associated with
goloid race.



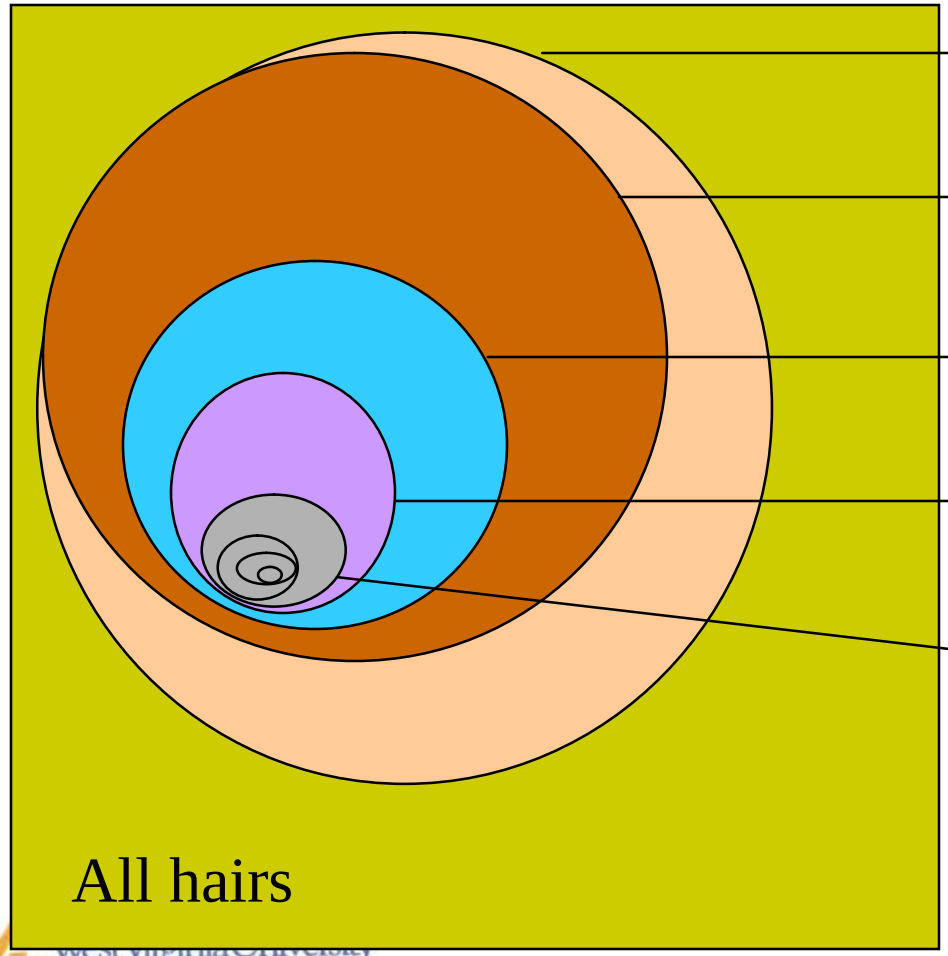

PIGMENT GAPPING

Medulla

- Presence or absence
- Thickness
- Fragmentary, discontinuous, continuous
- Clear or opaque
- Cellular or smooth



Ensembles of Class Traits[1]



All human hairs

All head hairs

All Caucasian HHs

All Brown COHHs

Next slide...

[1] Thornton, *JFS*, 1986

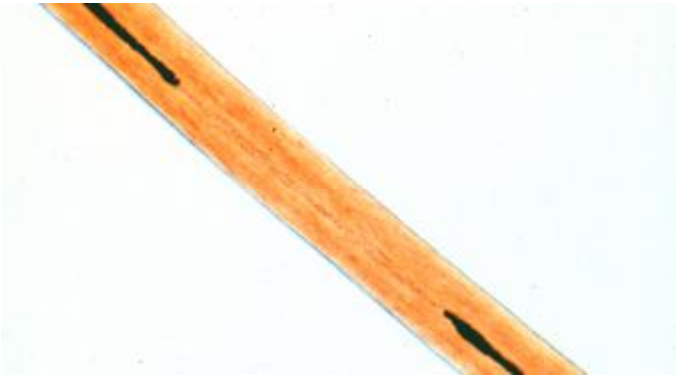
Ensemble of Class Traits

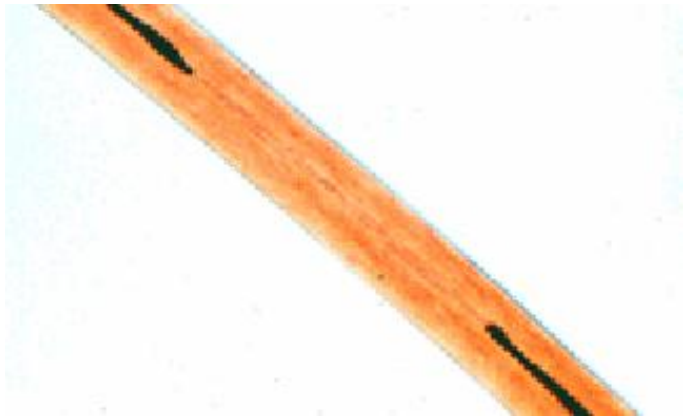
- **Root** **abundant fusi**
- **telogen**
- **anagen**
- **decomp**
- **stretched**
- **follicular tag**
- **Tip** **cut**
- **broken** **split**
- **pointed**
- **round**
- **Width** **coarse**
- **fine**
- **variation along shaft**
- **variation w/in sample**
- **Cuticle** **thickness**
- **variation in thickness**
- **clarity**
- **color**
- **Scales** **protrusion**
- **slight**
- **medium**
- **great**

- **length**
- **short**
- **medium**
- **long**
- **thickness**
- **thin**
- **medium**
- **thick**
- **fluctuation**
- **Medulla absent**
- **translucent**
- **fragmented**
- **transparent**
- **discontinuous**
- **opaque**
- **continuous**
- **cell shape**
- **thick**
- **thin**
- **medium**

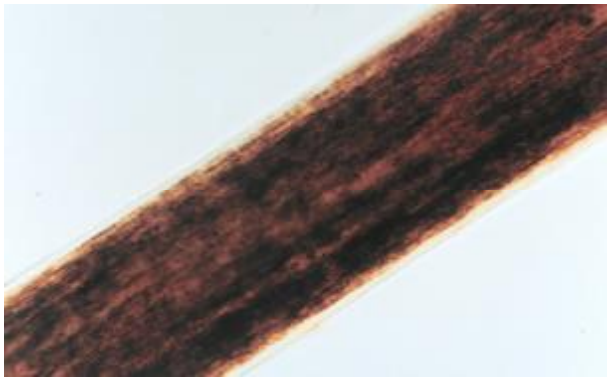
- Cortex cells prominent
- cells obscured
- Pigment size of granules
- shape of granules
- density
- local distribution
- patchy
- streaky
- chaining
- distribution w/in shaft
- gapping
- shallow
- short
- medium
- deep
- long
- pigment in cuticle
- Cosmetic bleached
- dyed
- length of time since treatment
- Special cracked cuticle
- ovoid bodies
- double medulla
- diseases
- vermin

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]**

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

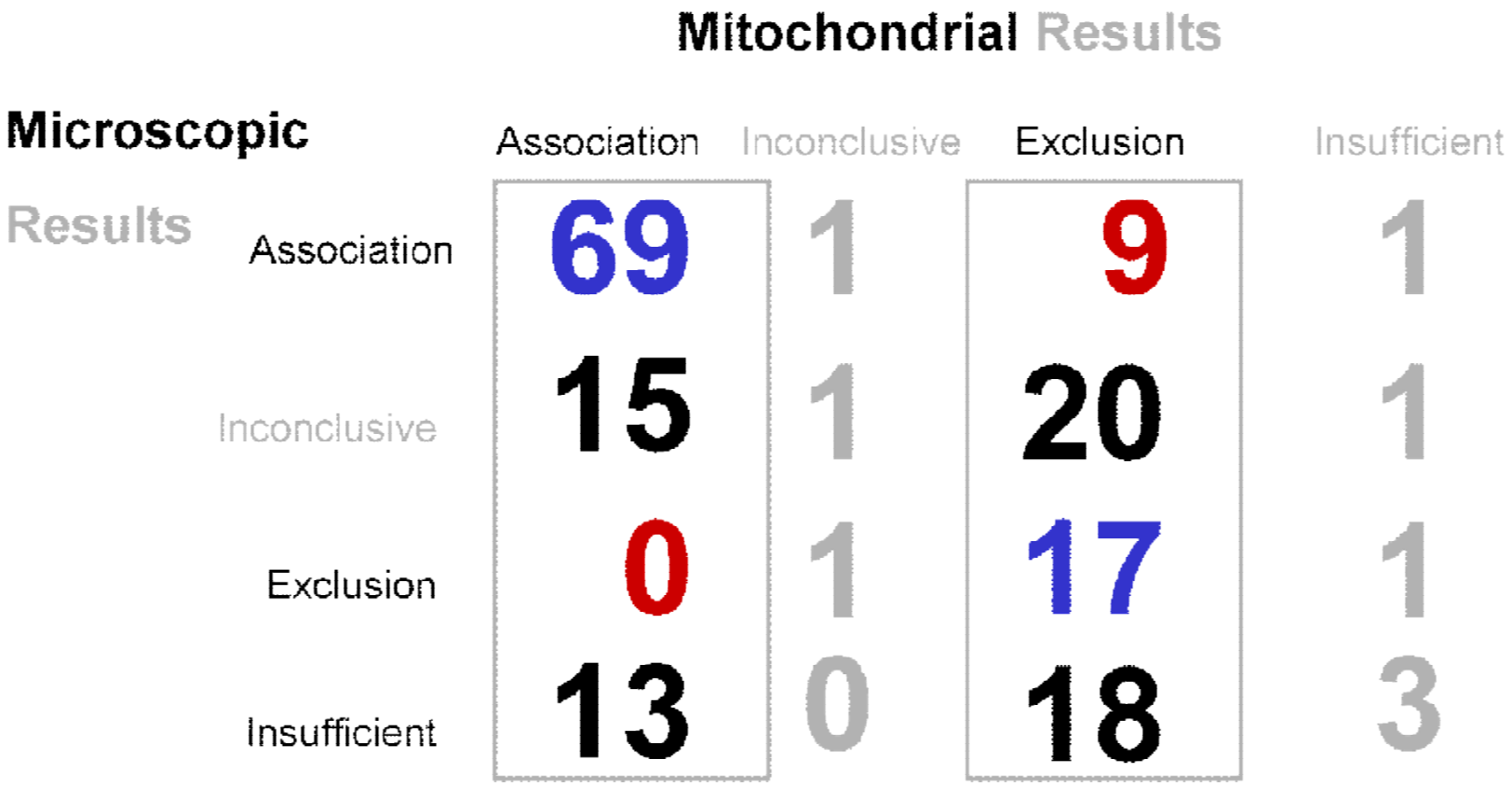
Reliability and reproducibility

- 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

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

Houck and Budowle, 2002



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;