# 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.
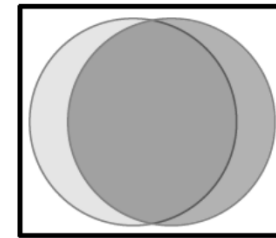
Because forensic science demonstrates associations between people, places, and things through the analysis of proxy data, essentially *all evidence is transfer evidence*.
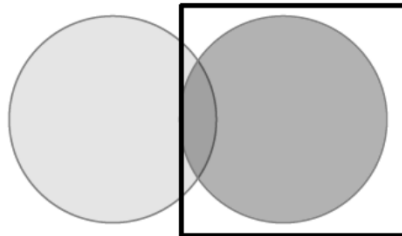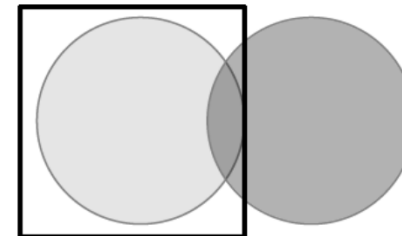
Relationships and Context
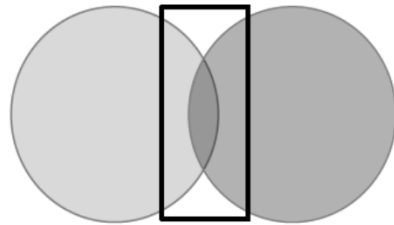
Victim and Criminal only interact at a Crime Scene unfamiliar to both
Ex. Sexual assault in an alley

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

V
C
S

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
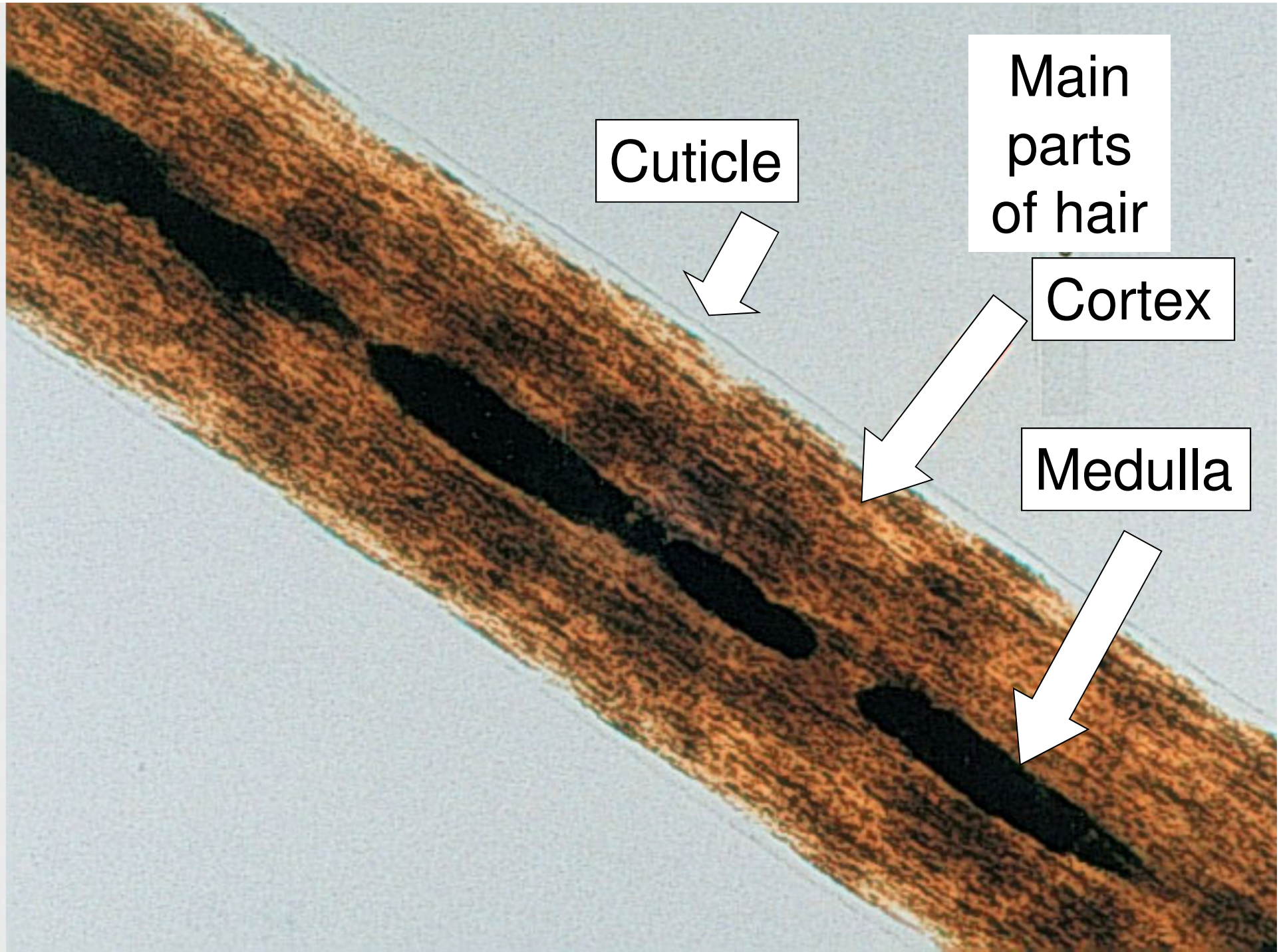- ## Microscopy
- ## Histology

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
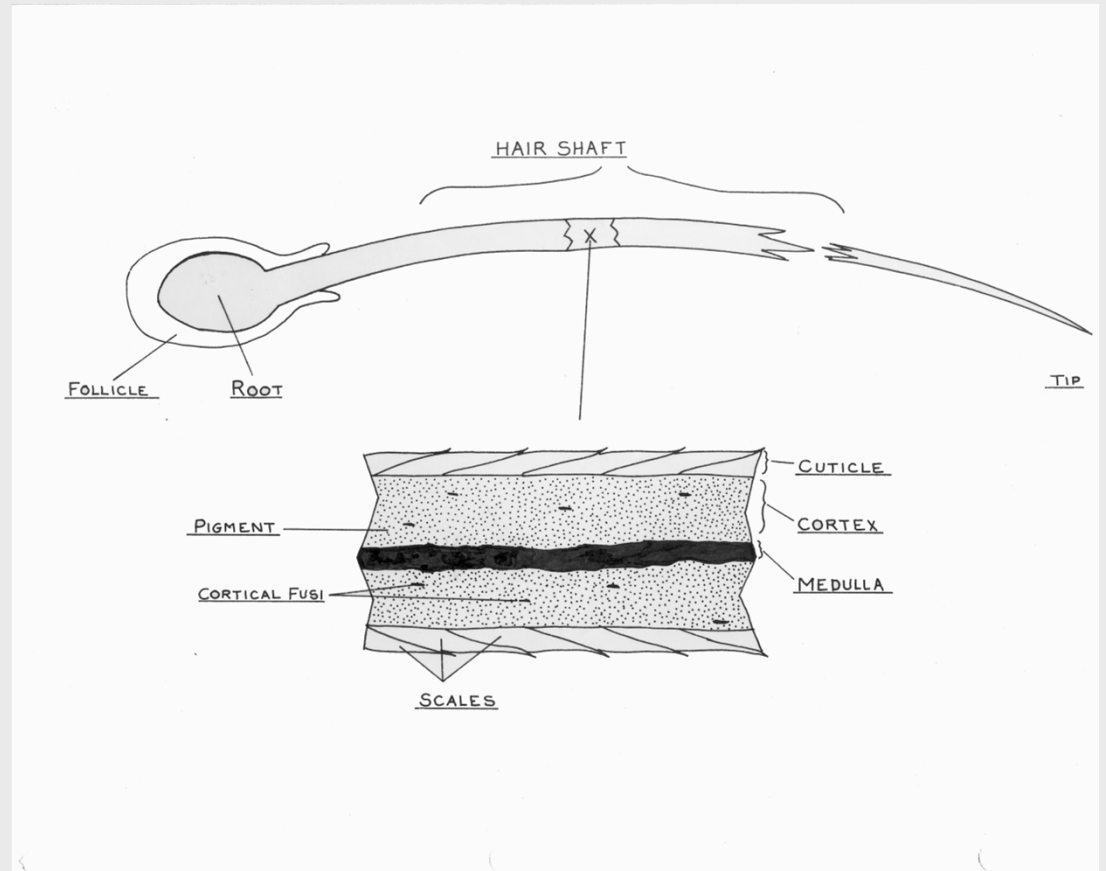
Cuticle

Main parts of hair

Cortex

Medulla

Growth Phases

Anagen   Catagen   Telogen
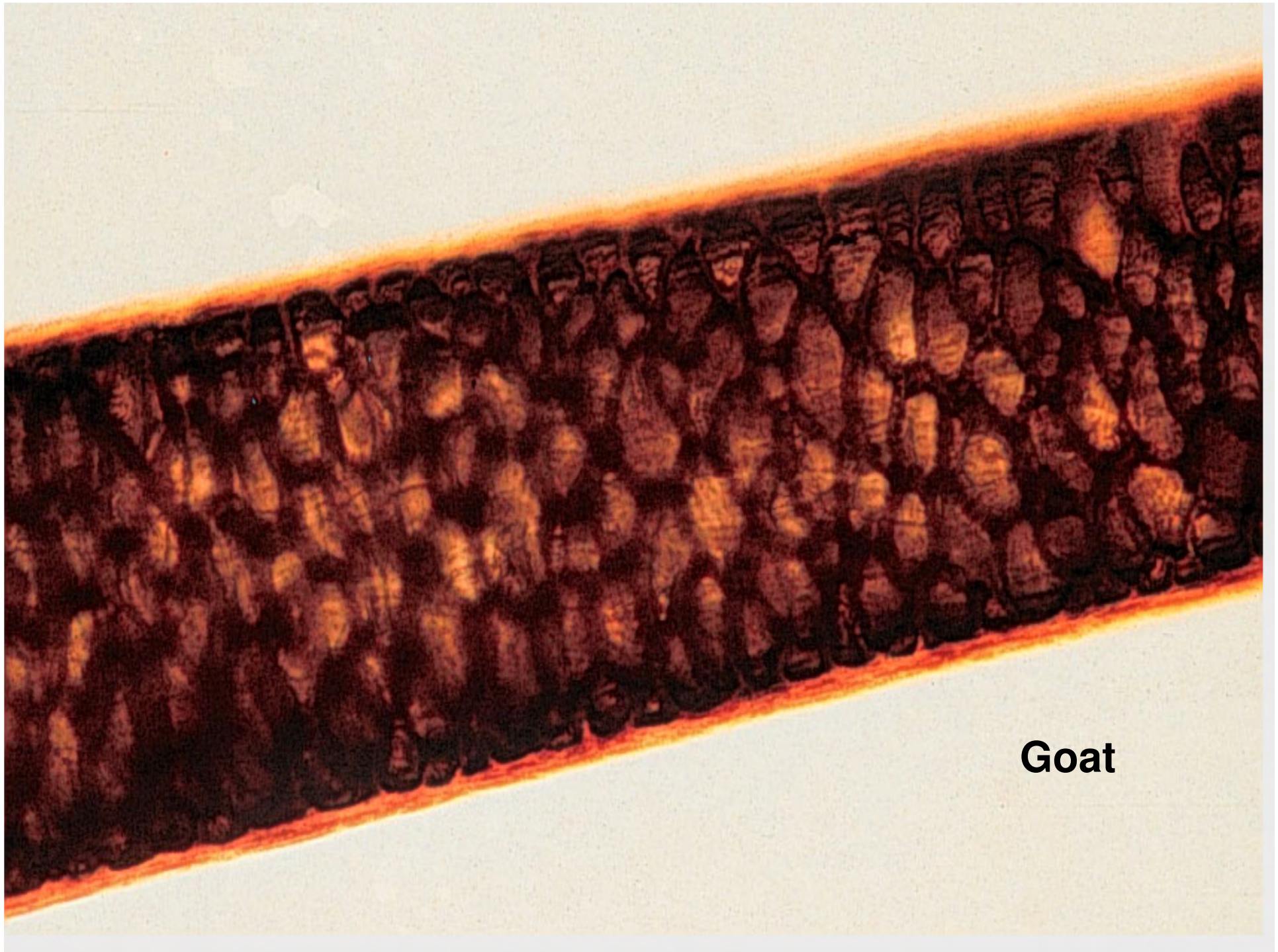
Is it human?

Human

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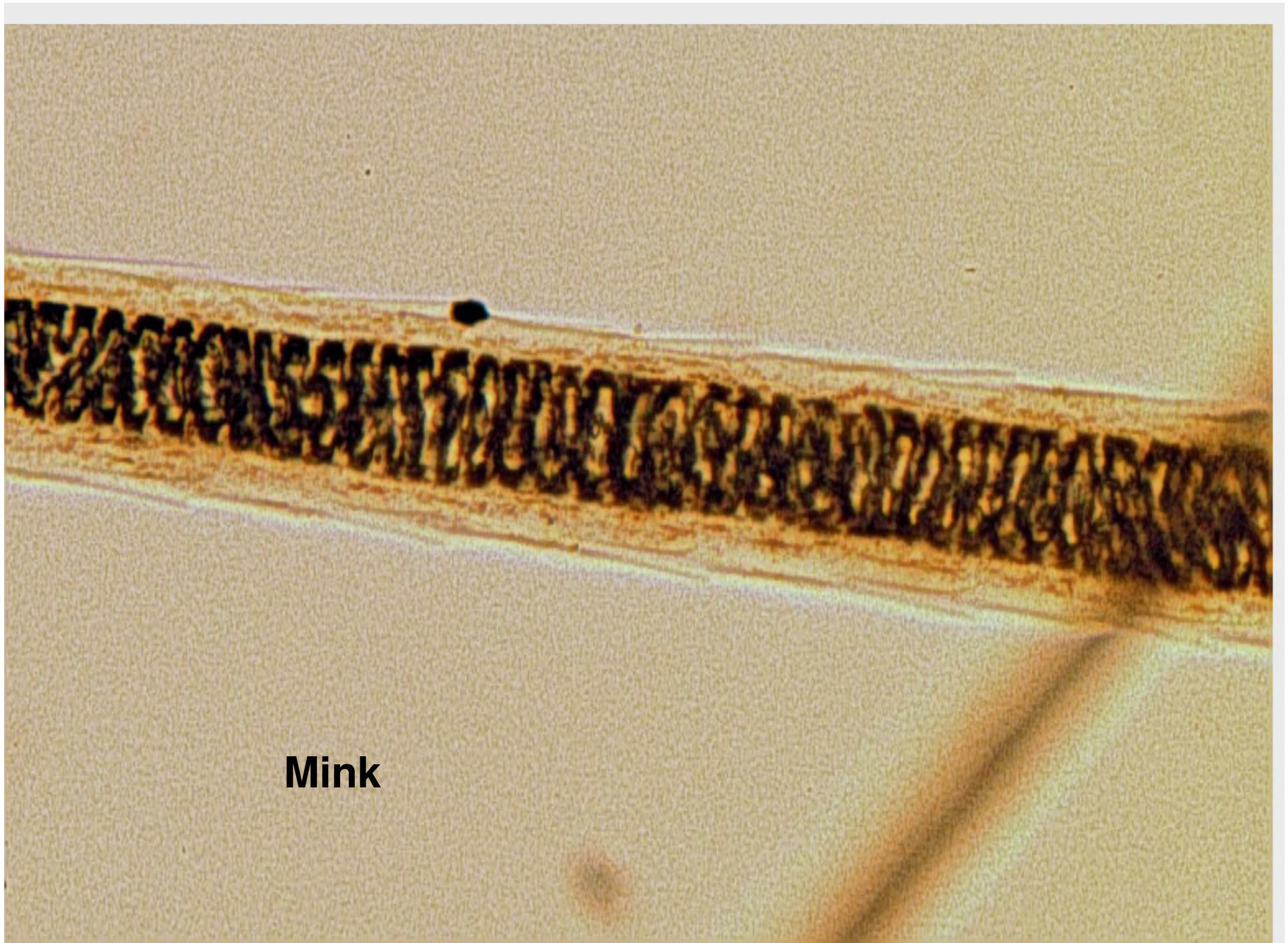- Amorphous medullation
- May be very long

Animal

- Shaft varies
- Pigment varies
- Color banding
- Varies by species
- Medullation varies with species
- Most are less than 3"

Dog

Goat

Mink

Deer
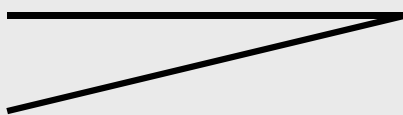
Human head hair

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

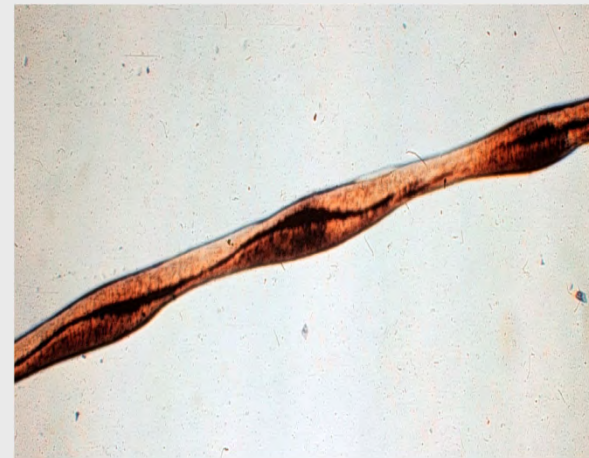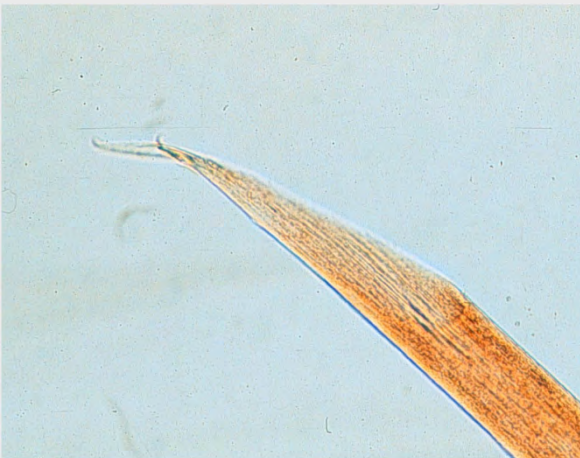# Damage/disease/treament
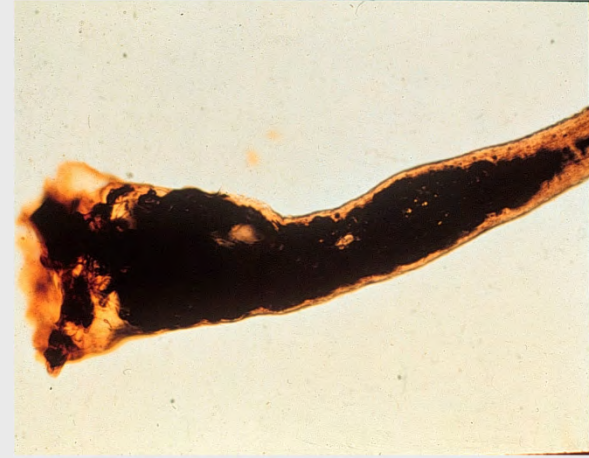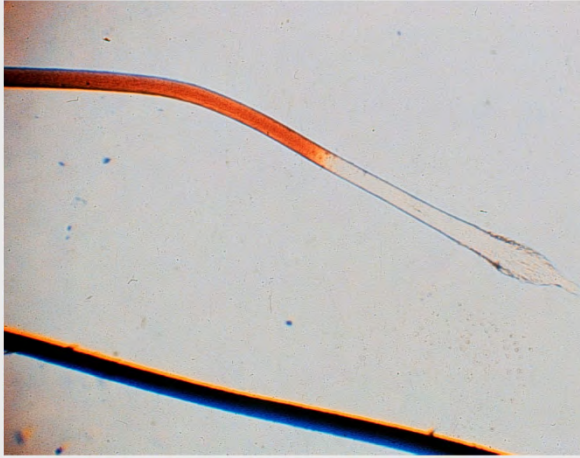
Is it suitable for comparison?

- 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 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
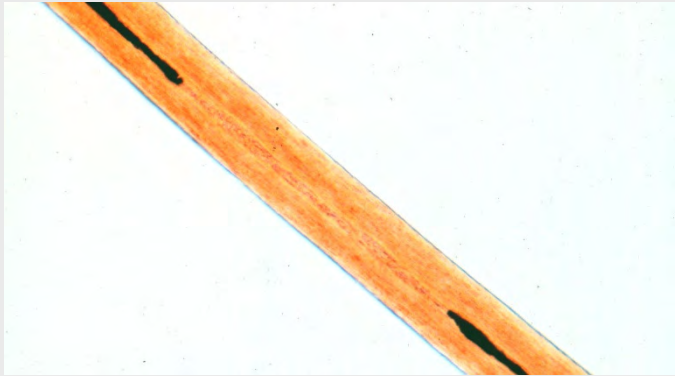
Exclusion
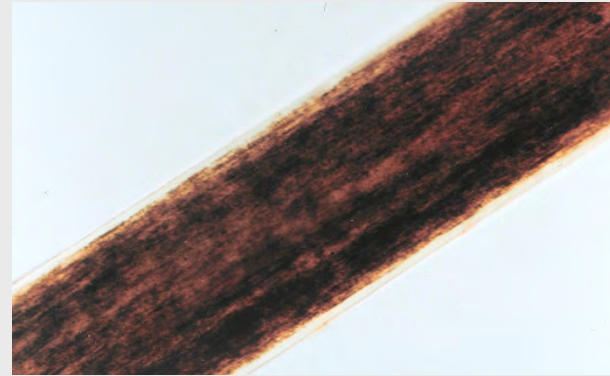
Conclusions

- ## 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.
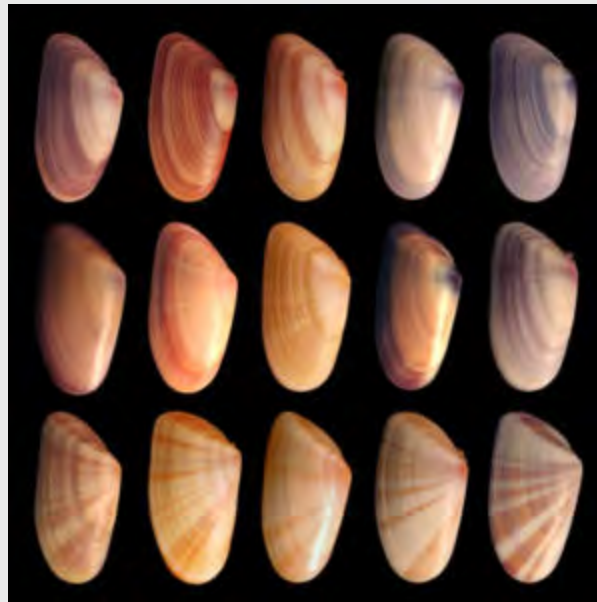
Houck and Budowle, 2002

	Microscopic	Mitochondrial
Association	80	97
Inconclusive	37	3
Exclusion	19	64
No Exam	34	6

Results of Microscopic and Mitochondrial DNA Analyses

Houck and Budowle, 2000

Mitochondrial Results

Microscopic Results

	Association	Inconclusive	Exclusion	Insufficient	Totals
Association	69	1	9	1	80
Inconclusive	15	1	20	1	37
Exclusion	0	1	17	1	19
No Exam	13	0	18	3	34
Totals	97	3	64	6	170

Results of Microscopic and Mitochondrial DNA Analyses by Method

Did the hair examiners make a mistake?
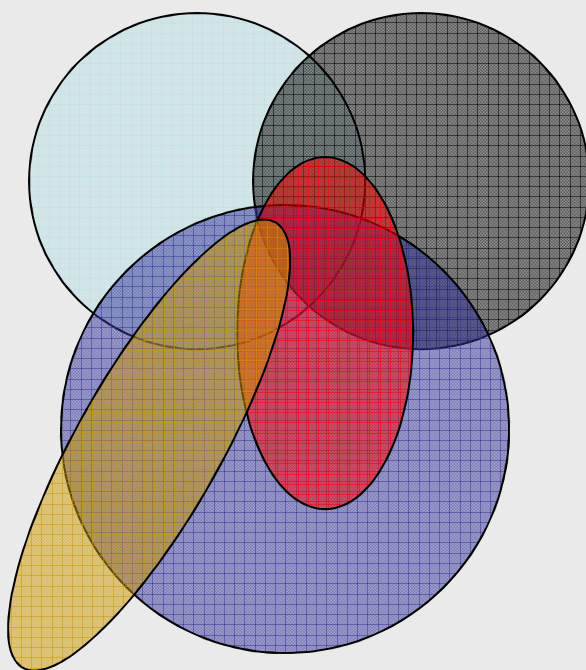
Hairs exhibit a multivariate phenotype

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

Melton, et al. *JFS* (2005) 50; 1

- 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.
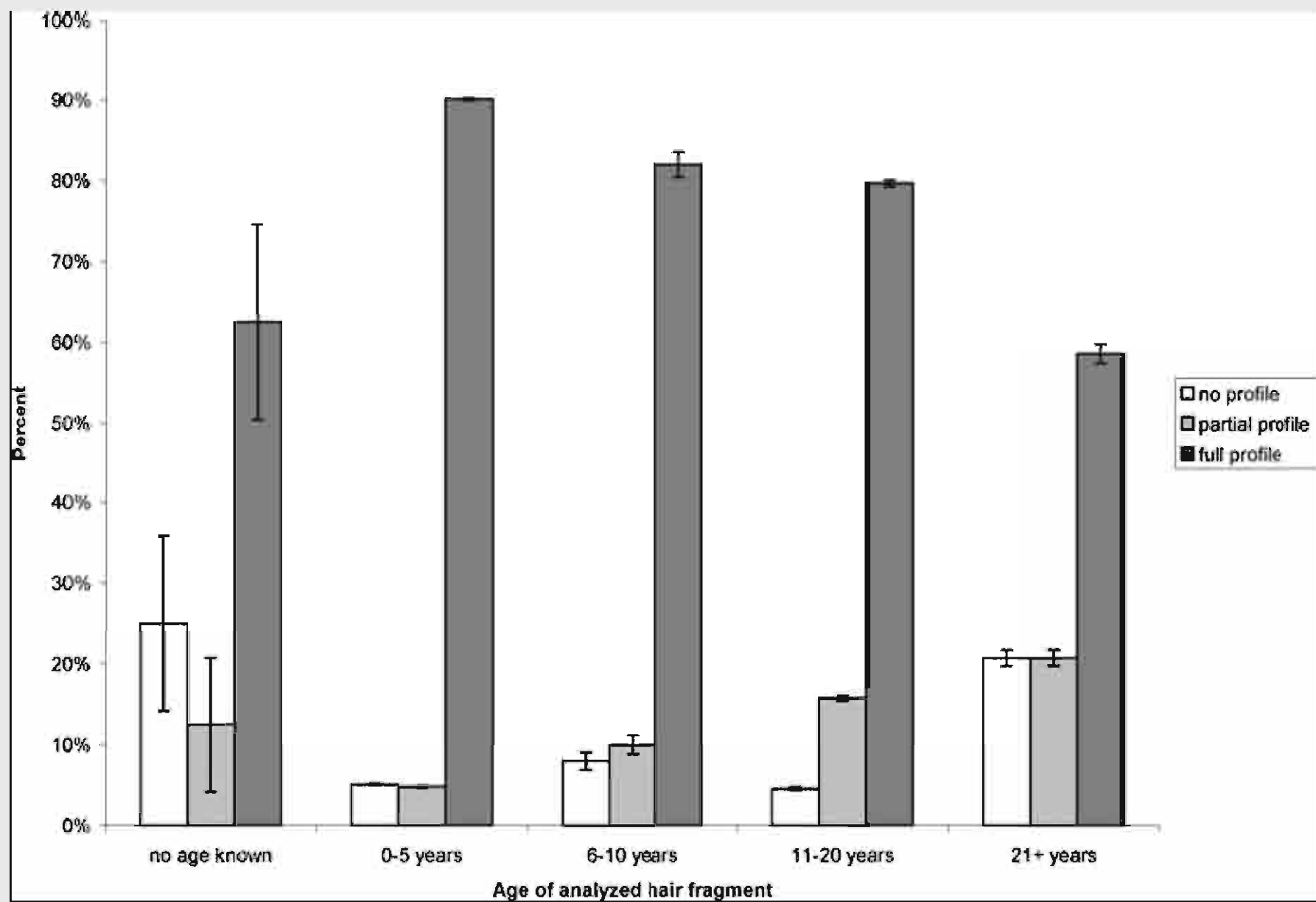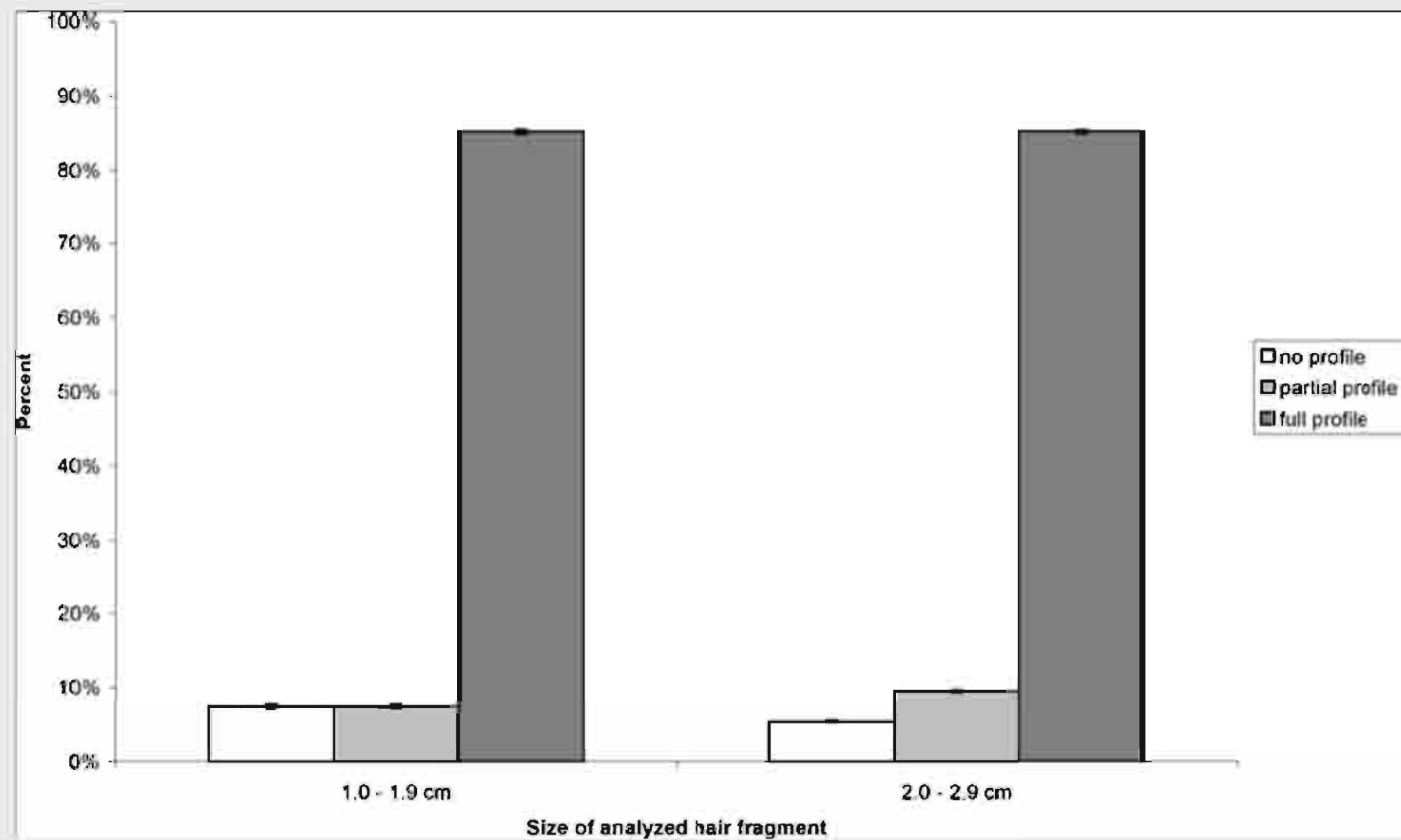
MtDNA and hair

- About 93% of hairs provide mtDNA 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