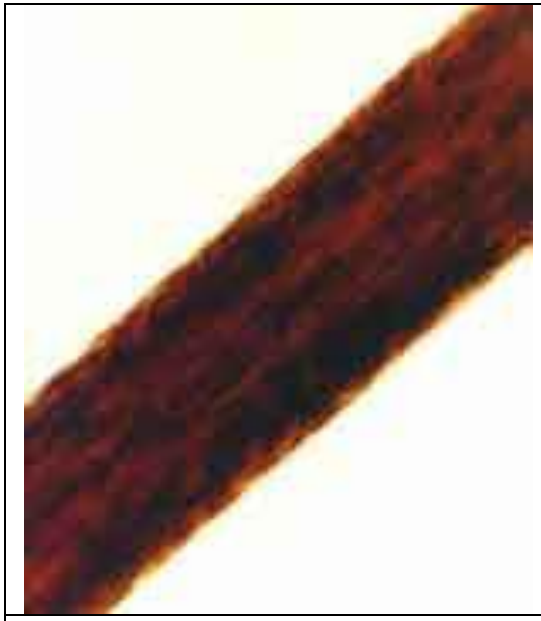
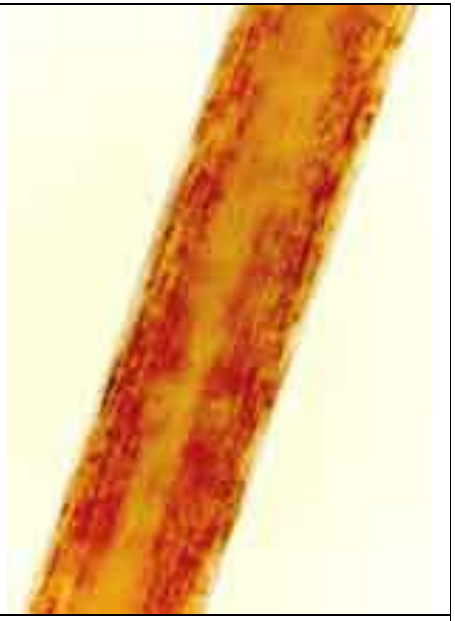
Hairs, Fibers, and Paint

Chapter 13

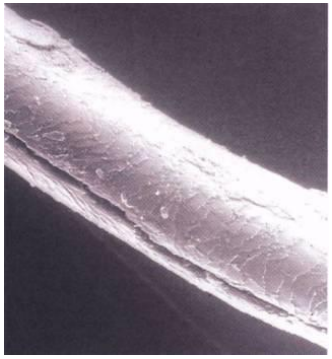
Hair is Class evidence

- Not individual specific
- Can be used as strong corroborative evidence but significant errors associated with microscopic evaluation of hair
- Appendage of the skin that grows from a follicle
- Resistant to chemical decomposition and long term structural stability
- Can often determine body area of origin
- Can sometimes determine racial origin
  - *Negroid (African)*
    - kinky with dense uneven pigment
    - flat to oval in shape
  - *Caucasian (European)*
    - straight or wavy fairly evenly distributed pigment
    - oval to round shape
  - *Mongoloid (Asian)*

Hair - Racial Identification

		
Mongoloid or Asian hair	Negroid or African hair	Caucasian or European hair

Grooved (African)



Collection of Hair Evidence

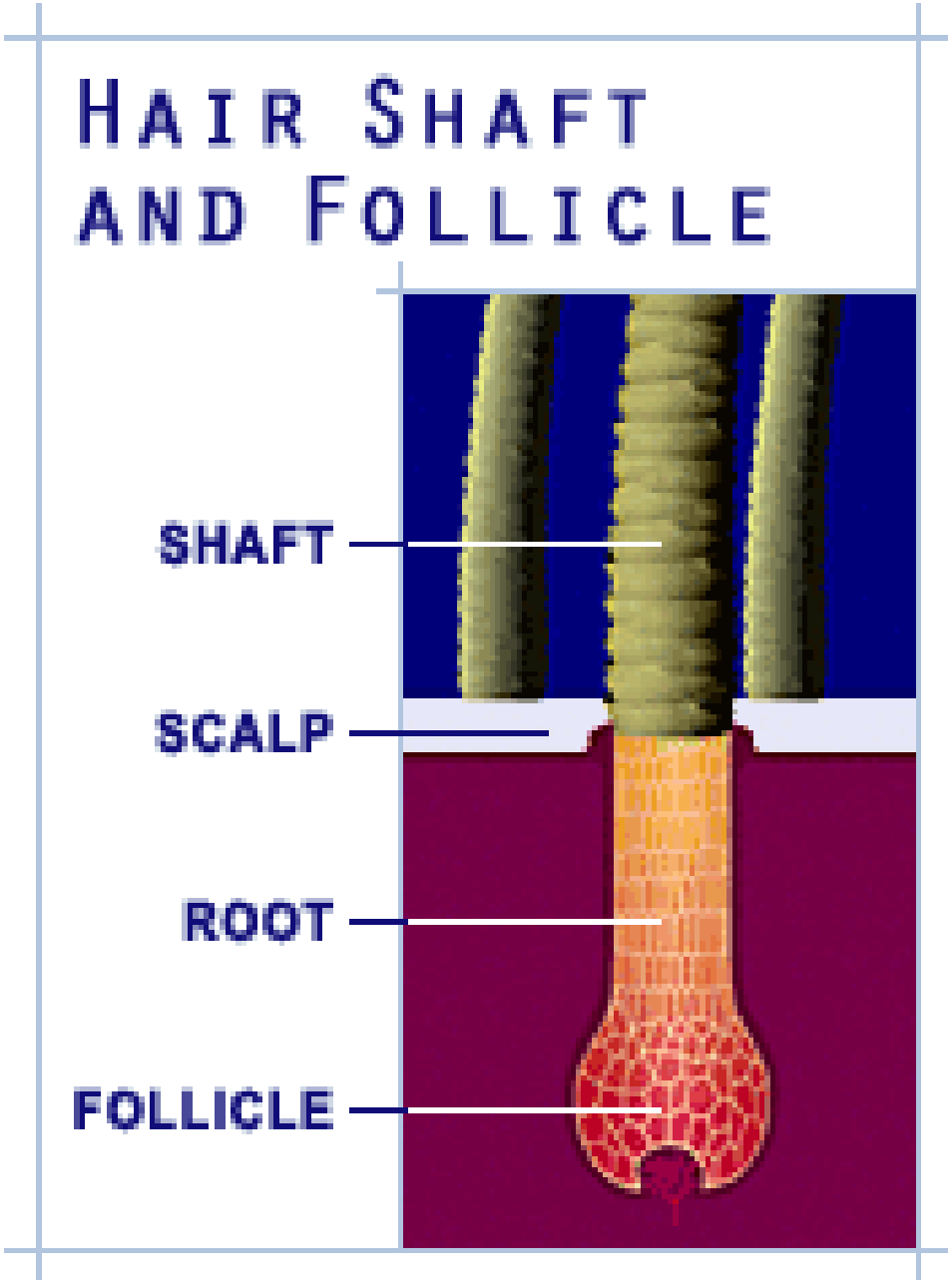
- An adequate number of control sample hairs from the victim and from those suspected of depositing hair at crime scene must accompany questioned hairs

- **Representative control samples**
  -50 full-length hairs from all areas of scalp
  -24 full-length pubic hairs

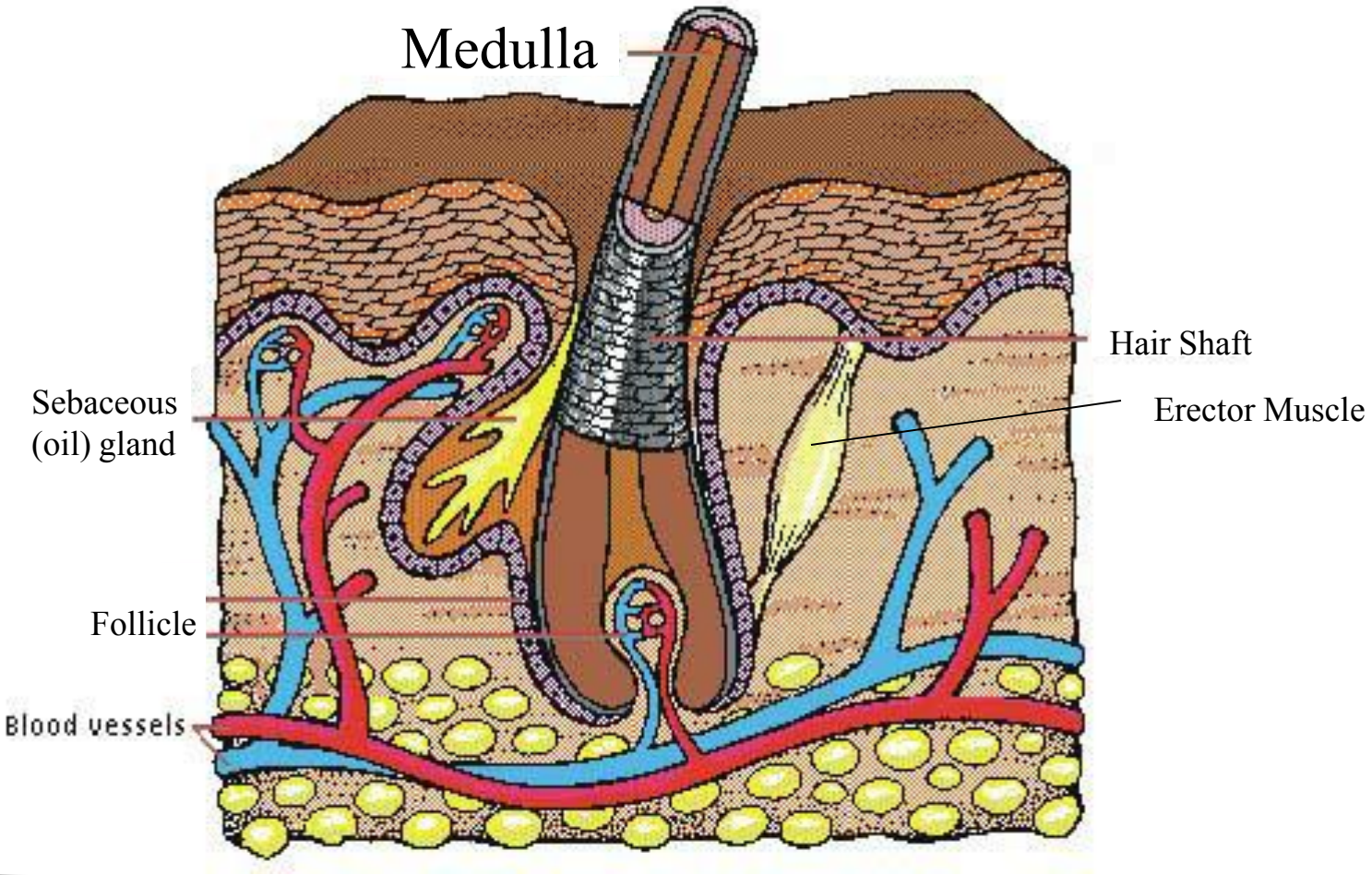
What Can Be Learned from Hair?

- Human or animal?
- Race
- Body area of origin
- Shed or forcibly removed
- Disease
- DNA
- Comparison to known samples

The Structure of Hair:

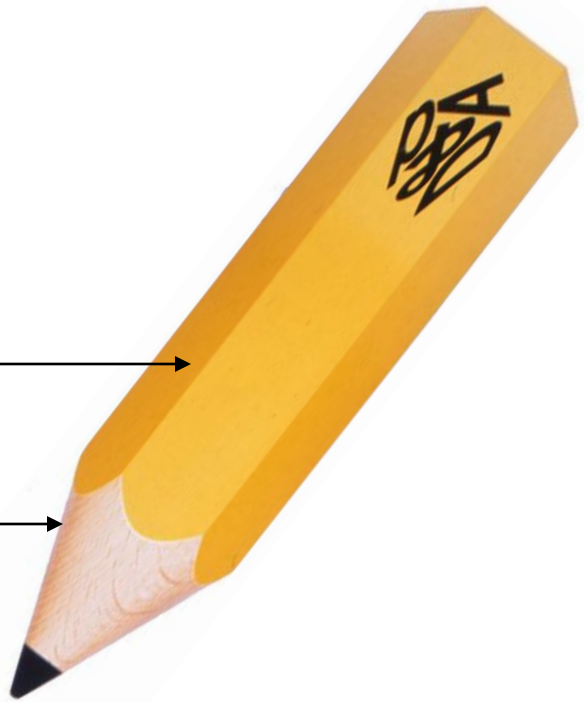


Hair Morphology



Three major parts of Hair:

- Cuticle
- Cortex
- Medulla



Cross Section of Hair

The **hair shaft** is comprised of 3 different layers:

Cuticle:

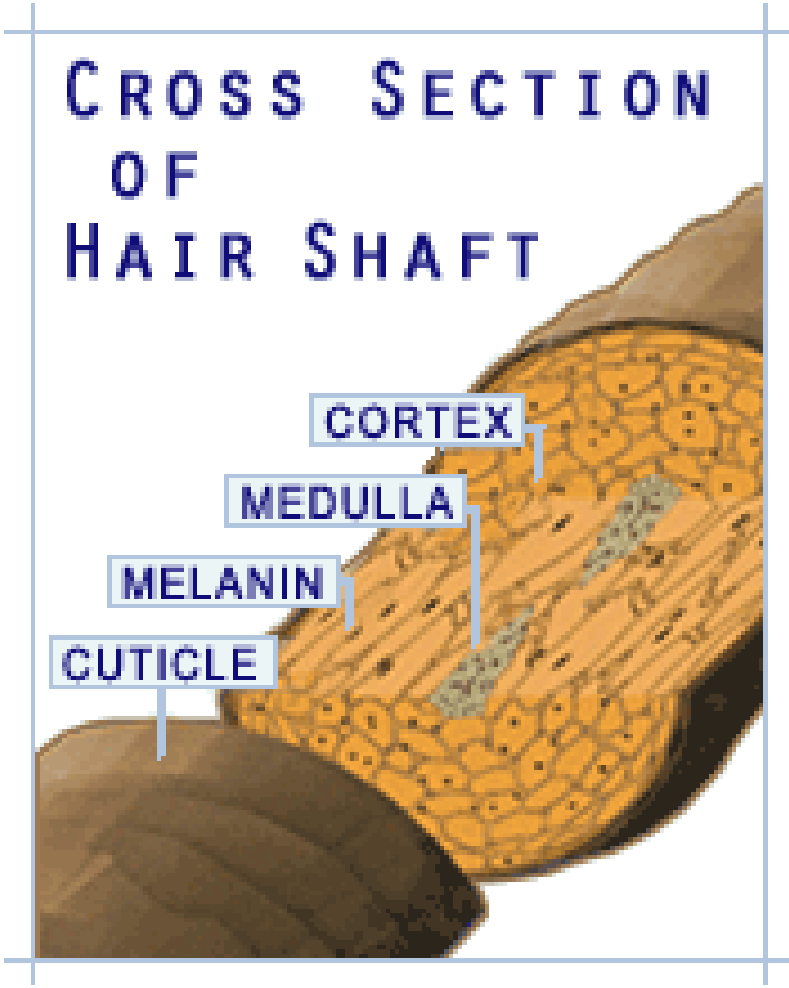
- Outer layer, which protects the hair.

Cortex:

- Middle layer
- Main body of shaft, contains pigment granules

Medulla:

- Central core of the hair.
- Composed of soft keratin.



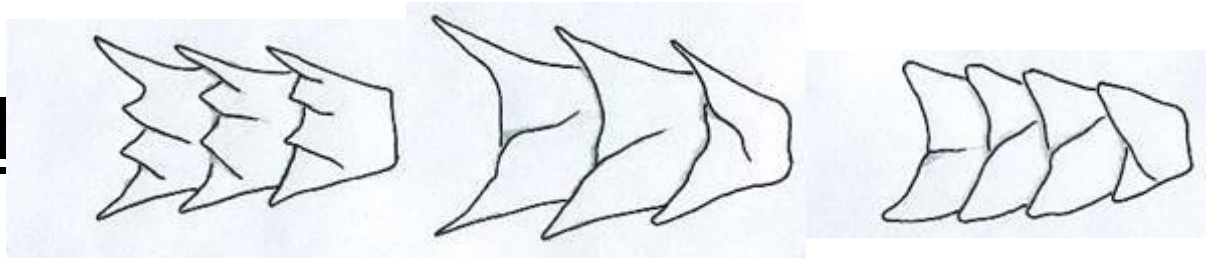
Three major parts of Hair: Cuticle

- Gives hair resistance to chemical breakdown and retains its structural features.
- Overlapping scales always point towards tip end of hair
- Scale pattern allows for differentiation of species
- Study scale by SEM or embedding into soft medium

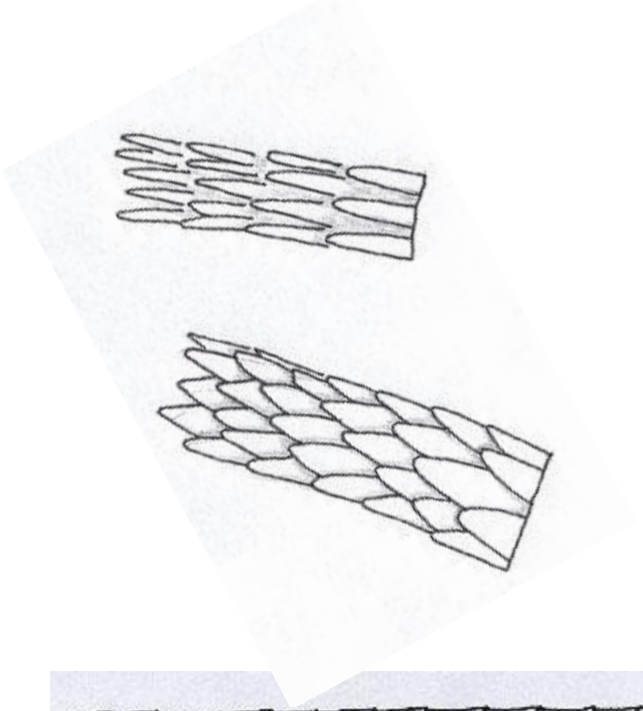
Cuticle Scale Patterns

- Coronal
  - crown-like scale pattern
    - Rodents, uncommon in humans
- Spinous
  - petal-like scales: triangular and protrude from hair shaft.
    - Mink, seals, cats
    - Never found in human hairs
- Imbricate
  - flattened scales: overlapping scales with narrow margins
    - Common in human hairs and many animal hairs

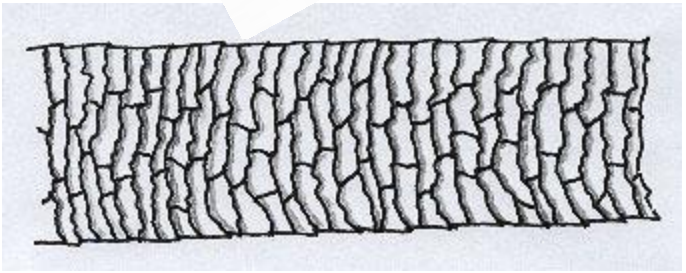
- Coronal



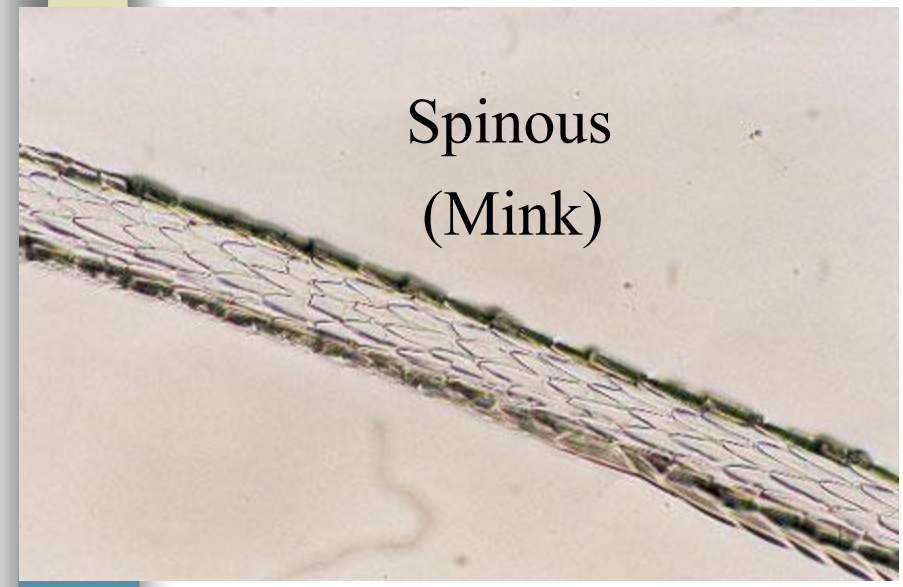
- Spinous

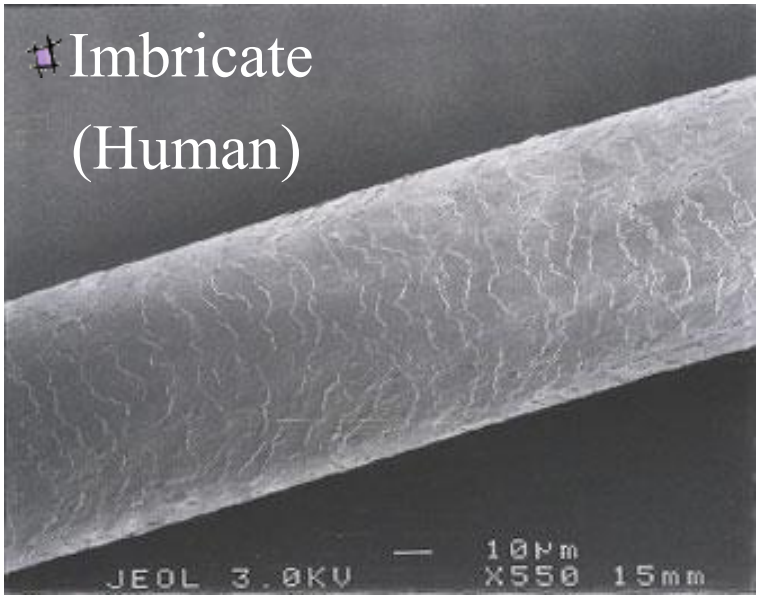


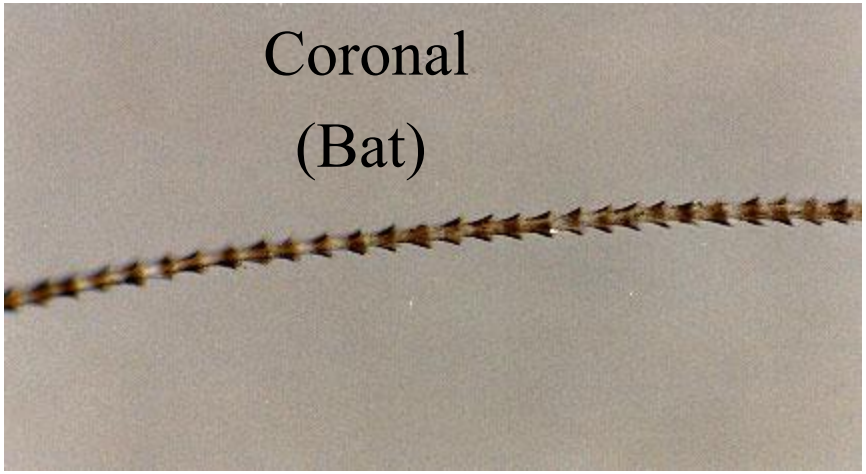
- Imbricate



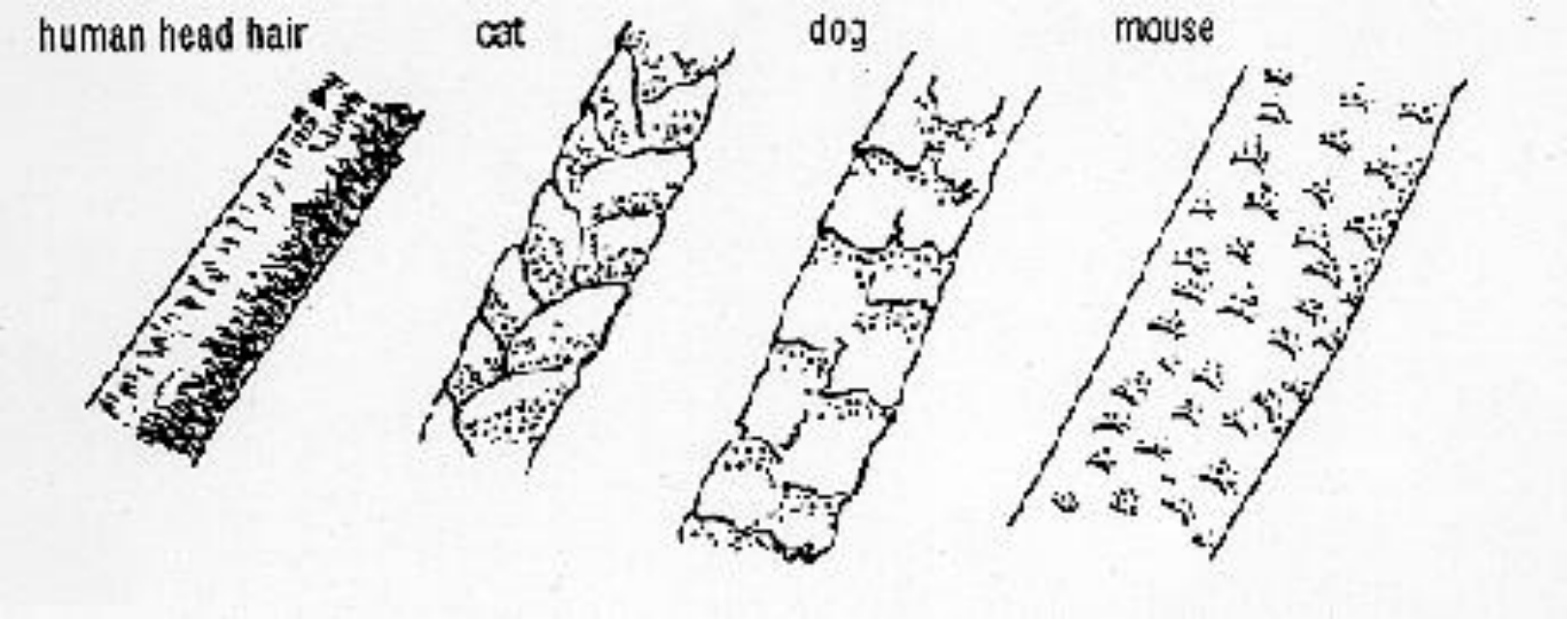
Identify the Cuticle Scale Patterns

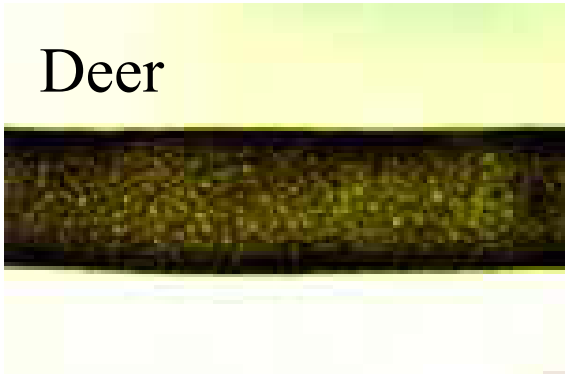






Hair - Species Identification





Three major parts of Hair: Cortex

- Cortex is the main part of the hair
- Has pigment granules
    - *Compare color, shape, distribution*
- Middle layer made up of long thin cells firmly attached to each other and arranged lengthwise
- Provides hair with strength, elasticity and determines the texture and quality of hair

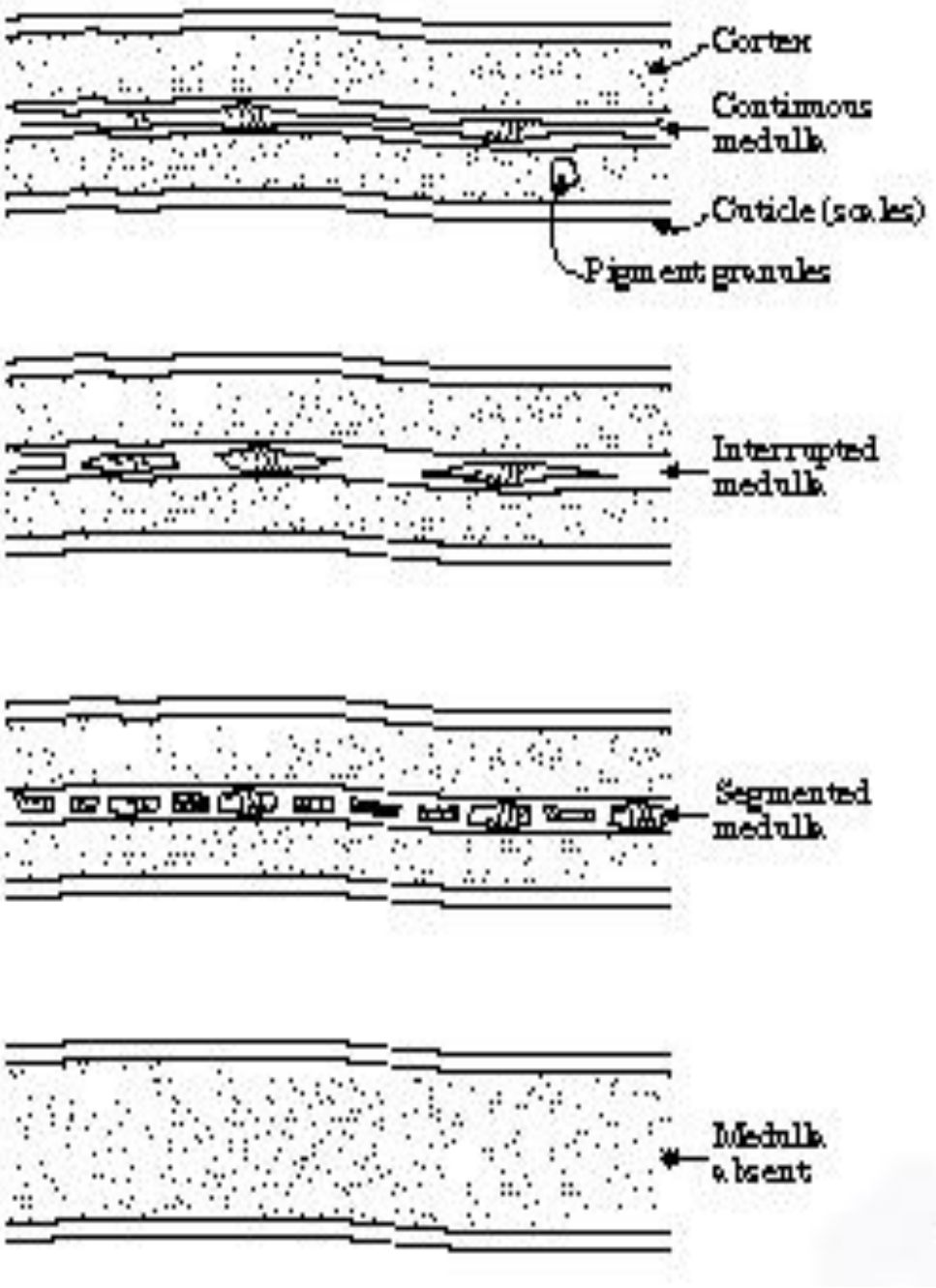
Three major parts of Hair: Medulla

- Cellular column running through middle of hair
- Shape - human and most animals have cylindrical shape
- Vary from person to person AND even among hairs from one person
- Best used to distinguish if a sample is human or animal.

  Human takes up <1/3 hair shaft
  Other animals takes up >1/2 hair shaft

Medulla types:

continuous, interrupted, fragmented (segmented) or absent


Cortex
Continuous medulla
Cuticle (scales)
Pigment granules
Interrupted medulla
Segmented medulla
Medulla absent

Hair Growth

- Three developmental stages:

1. *Anagen phase*: Active growth phase
   - up to 6 years (or as short as 3 mo. for eyelashes or arms).
   - Length of anagen determine max. hair length
   - About 85% of hair
   - Have about 100,000 head hairs

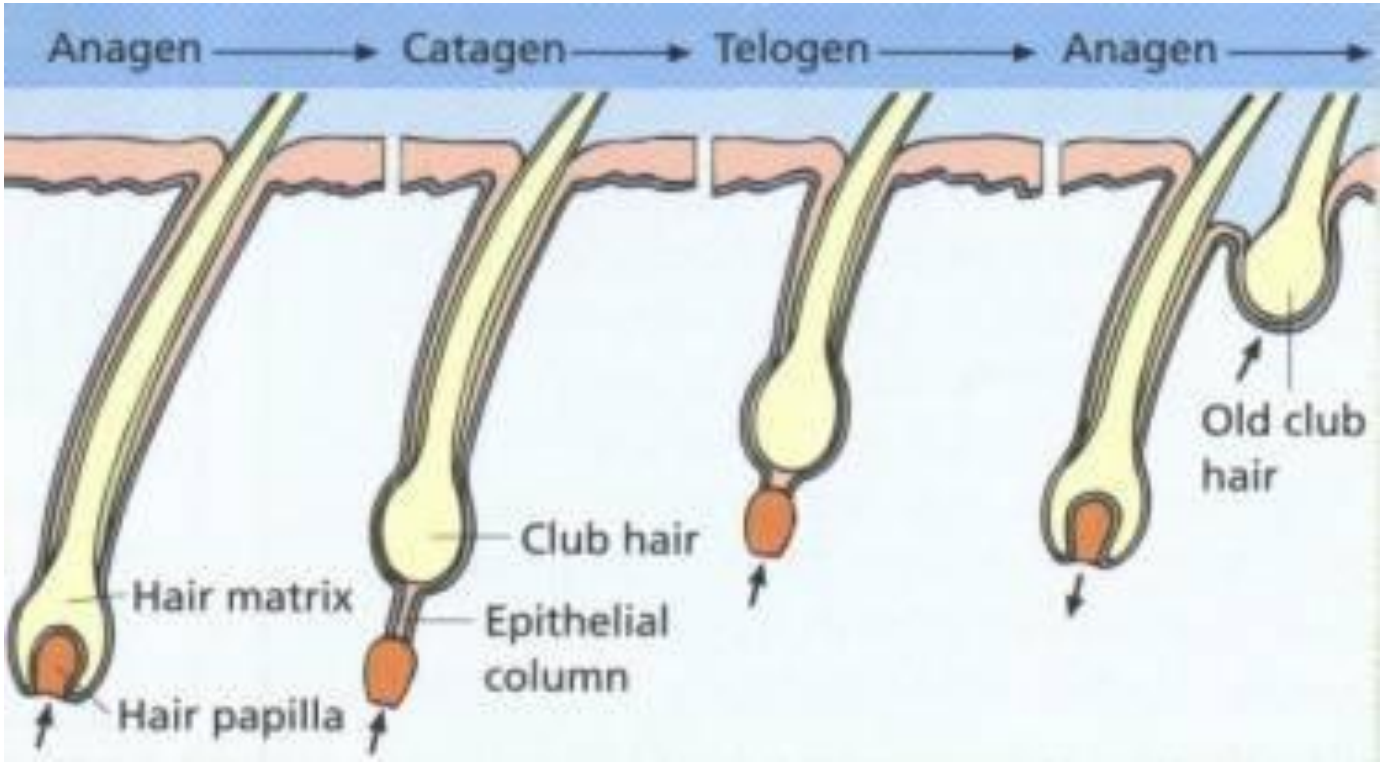
2. *Catagen phase*: Regressive phase

   Transition between active and loss stage (slowed growth)
   - usually up to several weeks.
   - 3-4% of hair

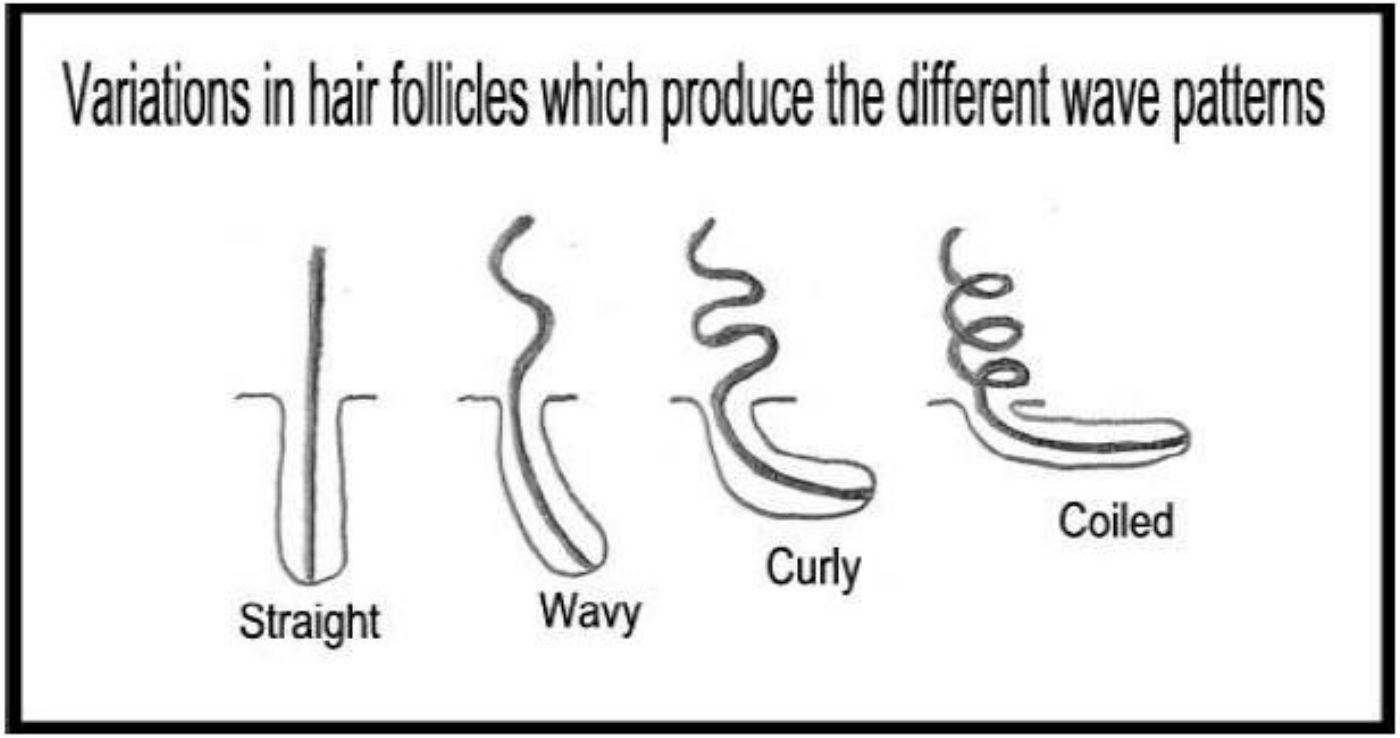
3. *Telogen phase*: Resting phase
   - Results in hair loss; final 2-6 months
   - 10-13% of hair

Hair Growth

- Animals that shed sychronize the telogen phases.
- Hair grows fairly uniformly at 0.5 mm/day (approximately 1cm/month or 6 in./year)



Types of hair follicles



Hair growth

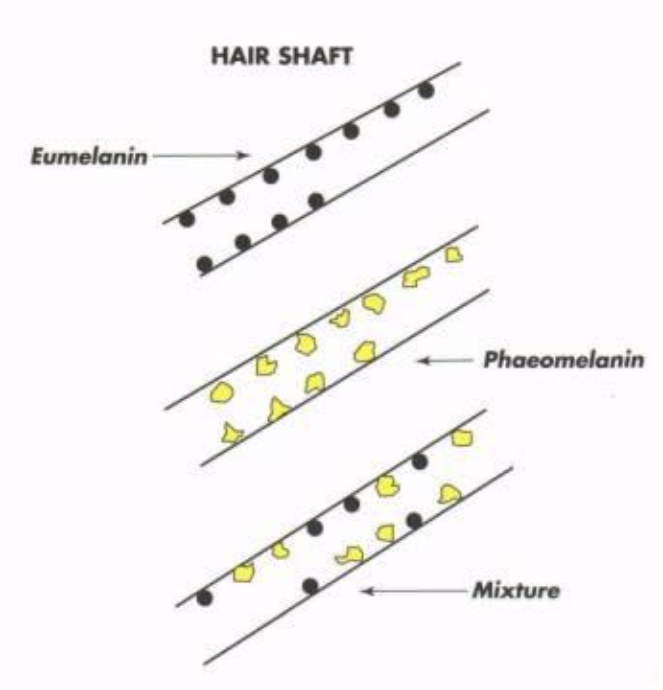
Differences in hair length depend on the length of anagen, which is genetically determined. These two people started off with hair of the same length and went without a haircut for 18 months: the man's hair grows only to his collar before it falls out naturally, but the woman's anagen period is clearly much longer *[reproduced from Diseases of the Hair and Scalp, A. Rook and R. Dawber (eds), 2nd edn, Oxford: Blackwell Scientific Publications, 1981]*

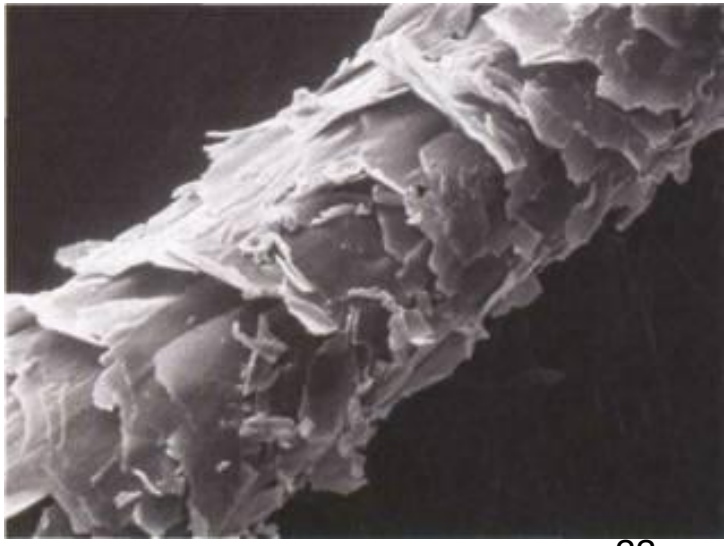
Metabolic Effects

(Left) This boy has a zinc deficiency, and his hair is very thin and sparse; (right) after treatment his hair is growing more strongly.

Hair Coloring

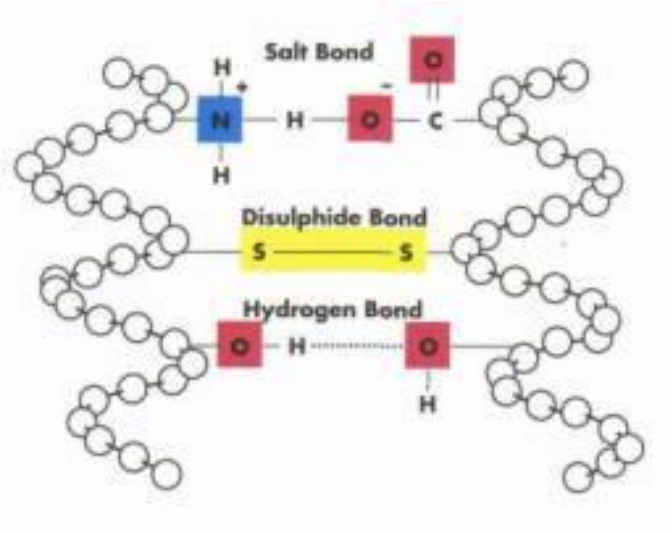
- 75% of adult females say they color their hair (7% in 1950).
- Permanent coloring requires chemicals to reach into the cortex (through the cuticle).
- They react with the cuticle, changing the color and becoming too large to be washed from the hair.
- Nasty chemicals involved (ammonia, hydrogen peroxide, etc).





Damaged by "Perming"

Hair “Perms”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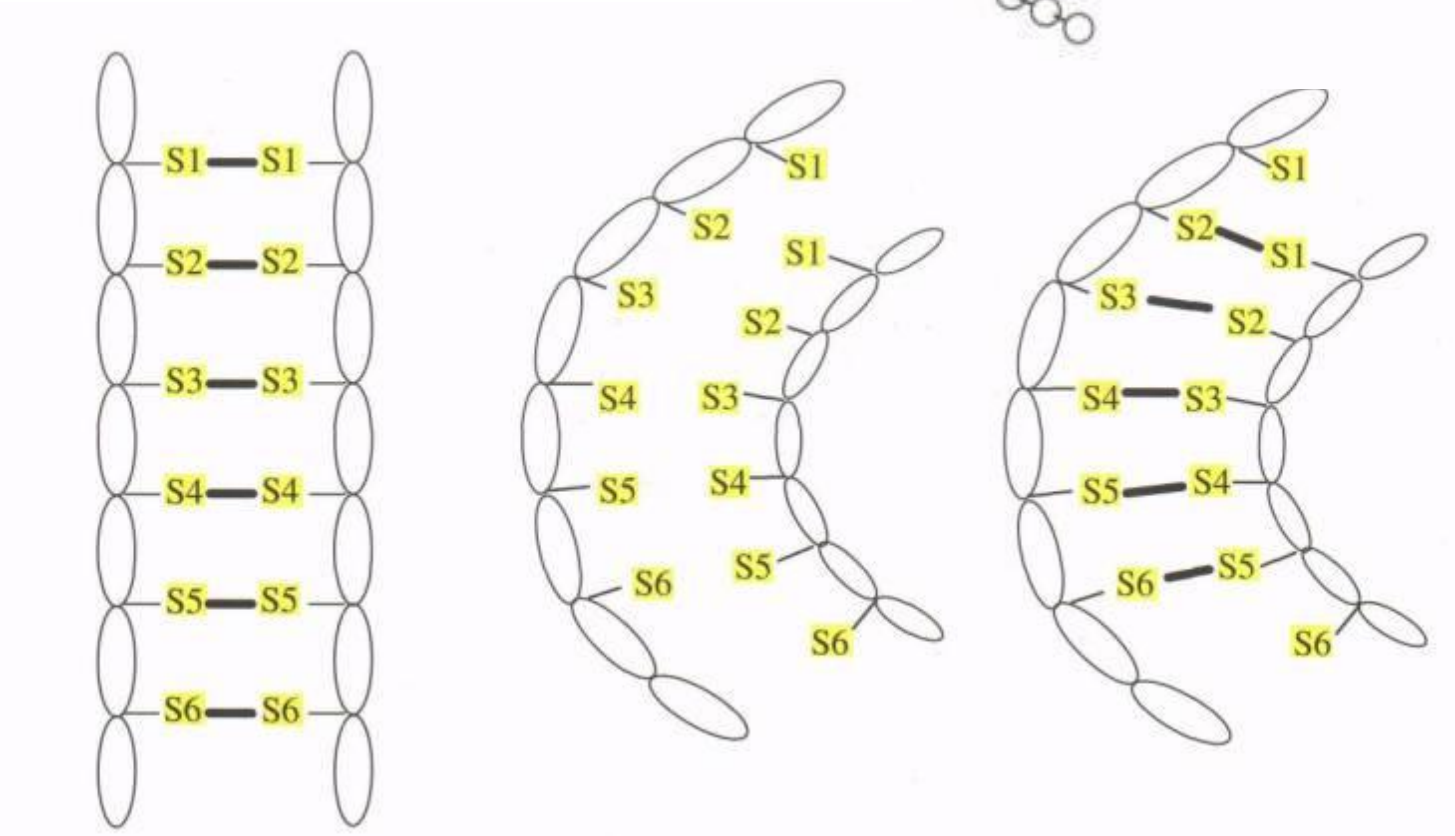
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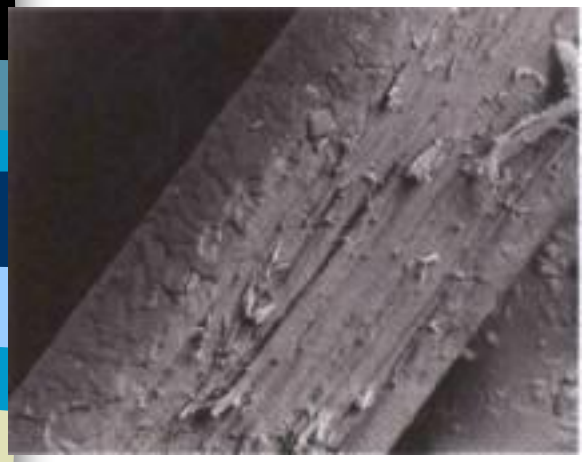
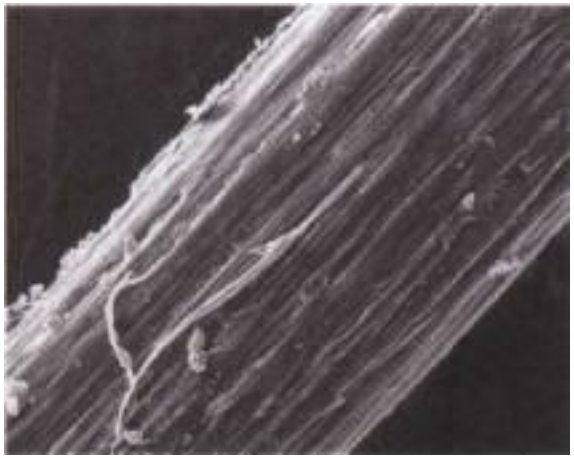
Hair

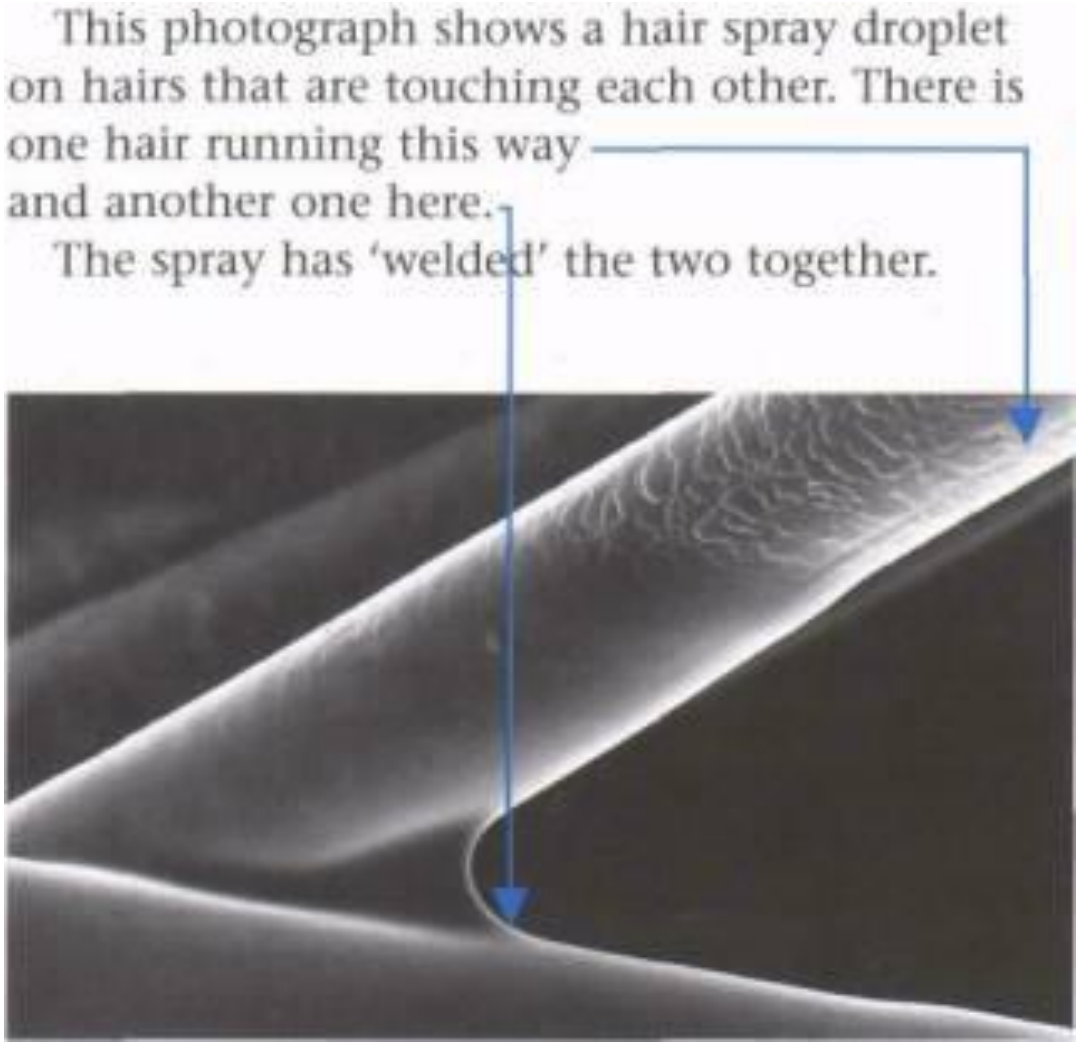
Split Ends

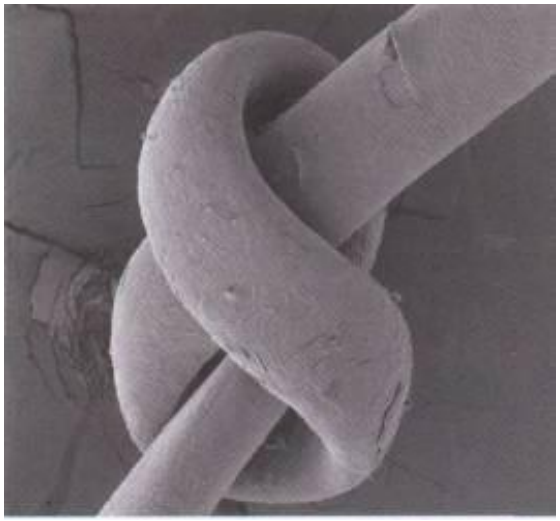


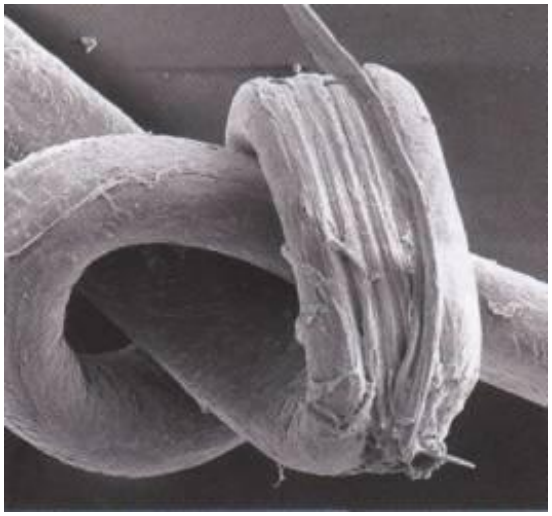


Severly Damaged Hair - The continuing destruction of the cortex of a hair: the long parallel bundles of keratin have been exposed and can be seen clearly.

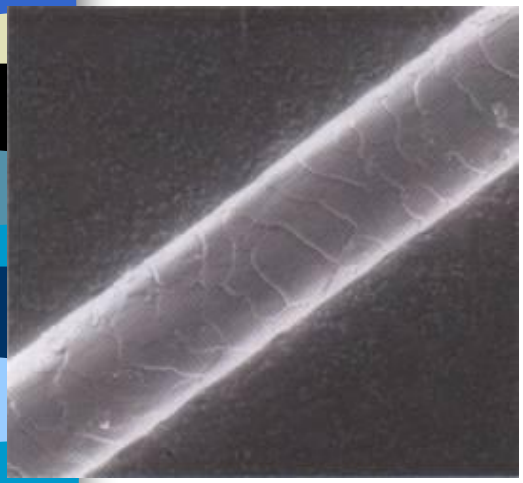
Hair


This photograph shows a hair spray droplet on hairs that are touching each other. There is one hair running this way
and another one here.
The spray has 'welded' the two together.

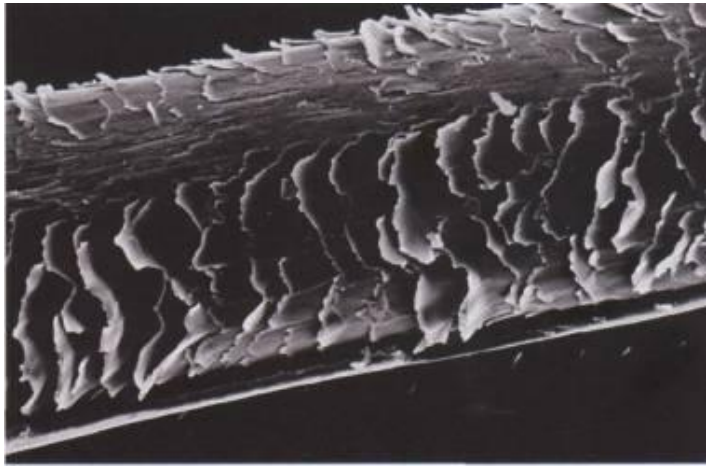




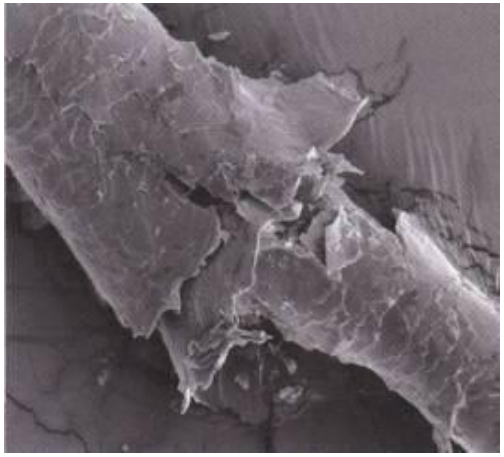
Knotting, associated with African hair



A healthy hair, its cuticle intact, taken from a newborn baby



Damaged cuticle, due to backcombing heavily sprayed hair



A hair shattered after severe perm damage

Hair - Sex Identification

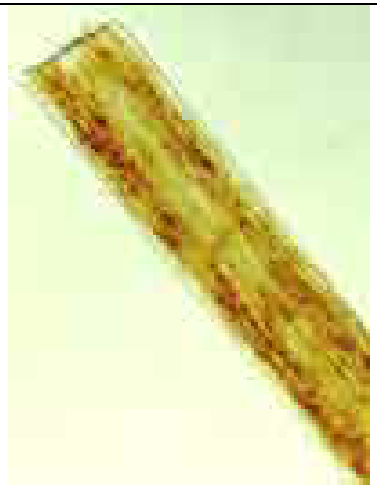
- Stained sex chromatin in the nuclei of human cells showing the female-indicative Barr body (bright spot, left)

Shedding vs. Removal By Force

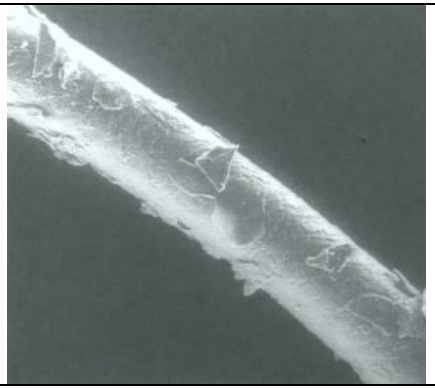
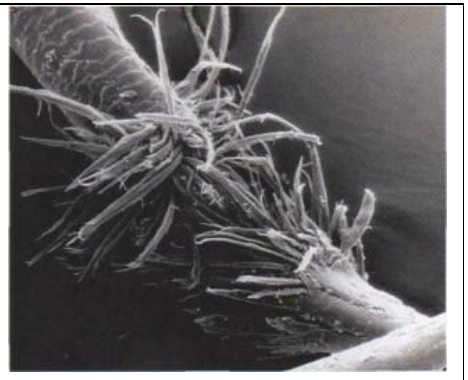
*Presence of follicular tissue on root indicative of forcible removal by a person or by a comb

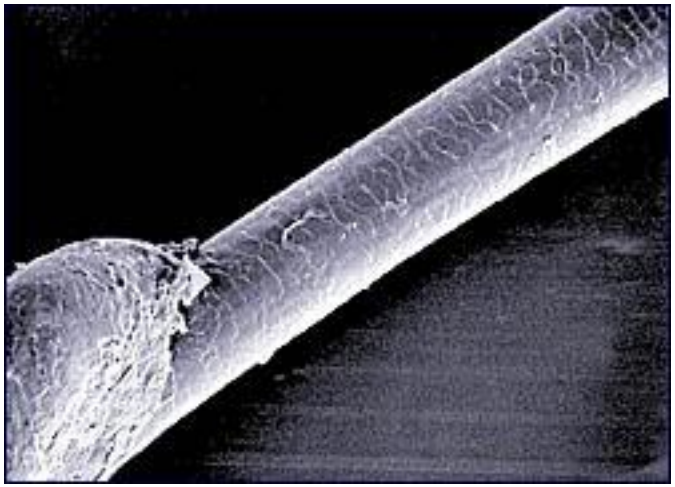
Naturally shed hairs, such as a head hair dislodged through combing, display undamaged, club-shaped roots.	A hair forcibly removed from the scalp will exhibit stretching and damage to the root area.	Forcibly removed hairs may have tissue attached.

Hair

		
A split hair	A hair with a cut tip	A postmortem root band

Hair

		
Cross-sections of three hairs, all of different racial types: (left) Asian, (centre) Caucasoid, (right) African.[5]	Hair that has not been washed for some time.[5]	Heat damaged hair.[5]



A micrograph of a hair shaft. Note the layered cuticle on the shaft and the bulb at the bottom

Hair as a Source of DNA?

Nuclear DNA:

- hair root or aka **follicular tag**: a translucent piece of tissue surrounding the hair's shaft near the root.

Mitochondrial DNA:

- located outside of the nucleus
- Multiple per cell
- Maternally inherited

Forensic Hair Analysis

- In 1936 the wife of an NBC executive was killed in their Manhattan brownstone. She had been strangled with her pajama top and left in the bathroom. Indications were that she had known her killer, and when there appeared to be few clues except some twine used to bind her, a chemist was brought in to examine the crime scene.
- In the bedroom he found only one strand, half an inch long, of stiff white hair, which he soon identified through a microscope as horsehair. Since two furniture movers had delivered a horsehair couch that morning and it was those men who reported the body, the detective in charge speculated that one of them had paid an earlier call. He identified the likely culprit and then found a connection via the piece of twine, because it had sufficiently distinctive markings to be traced to a manufacturer and distributor. It turned out that the same twine had been sold to the furniture store. Using this evidence to put pressure on the suspect, the detective got the confession he needed for conviction.

Fiber as "Class" Evidence

Fiber evidence, like hair, **does not** possess a sufficient number of unique, individual characteristics to be positively associated with a particular person to the exclusion of all others!

Examining Fibers

- Most of fiber analysis is done through microscopic examinations

- There are not as many parts to fiber as there are with hair, but that does not make it less valuable

- When analyzing under a microscope, you try to identify
  - Color
  - Texture
  - Diameter
  - Shape pattern
  - Cross sectional appearance
  - Surface characteristics
  - Presence or absence of delustering particles (usually titanium dioxide)

- Once this is done, type and origin of the fiber may become more evident

- Fibers may also be evaluated in the following ways
    - Physical match- used when larger pieces are available and can be physically matched by site, shape, and size
    - Micro-chemical tests: Various chemical reagents are used for determining physical characteristics of the fiber
        - Melting point
        - Density
        - Ash formation
        - Tensile strength
        - Solubility
        - Infrared and visible spectrum

Unfortunately, these tests destroy the fiber!

Types of Fibers

The two broadest groupings of fibers are Natural and Man-Made:

- **Natural Fibers** –derived in whole from animal or plant sources

  Examples: wool/cotton/silk

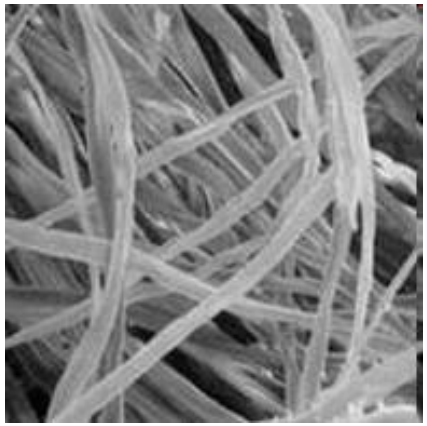
- **Man-Made fibers-** fibers made totally from man-made materials (synthetic fibers) or chemically altered natural materials (regenerated or derived fibers)

  Synthetic: nylon, polyester, acrylic

  Regenerated: rayon First man-made fiber in 1911 (derived from natural material-cellulose)

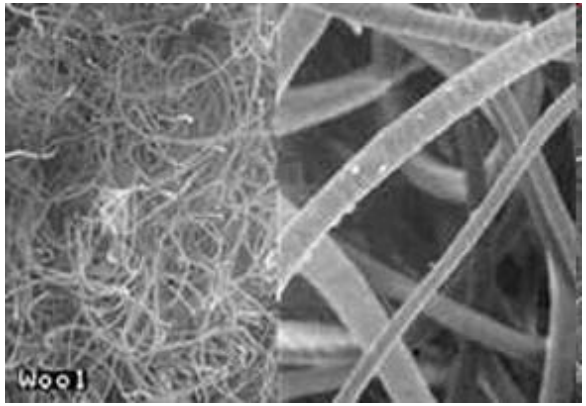
Natural Fibers

Many different **natural** fibers that come from plants and animals are used in the production of fabric.



Cotton fibers are the plant fibers most commonly used in textile materials

The animal fiber most frequently used in the production of textile materials is **wool**, and the most common wool fibers originate from sheep.



Natural Fibers in Common Use

Vegetable Fibers

- Cotton
- Flax
- Hemp
- Jute
- Leaf Fibers
- Sisal
- Cattail

Animal Fibers

- Wool
- Alpaca
- Mohair
- Cashmere
- Angora
- Camel
- Silk

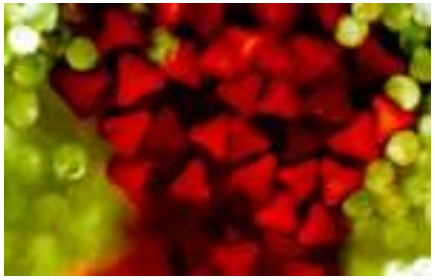
Mineral Fibers

- Asbestos
- Fiberglass (largely manmade)

Synthetic Fibers

More than half of all fibers used in the production of textile materials are synthetic or **man-made**.

Nylon, rayon, and polyester are all examples of **synthetic** fibers.



Cross-section of a man-made fiber

Fibers under a microscope

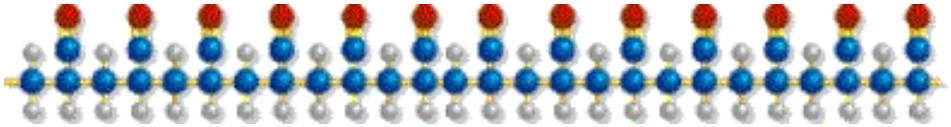
Images: http://www.trashforteaching.org/phpstore/product_images/YarnWS.JPG
http://www.fbi.gov/hq/lab/fsc/backissu/july2000/deedric3.htm#Fiber%20Evidence
http://www.jivepuppi.com/images/fiber_evidence.jpg

Characteristics of Synthetic Fibers: Polymers

Polymer - large, high molecular weight molecule formed by joining together a large number of molecules of low molecular weight

"poly" means many

"mer" means unit



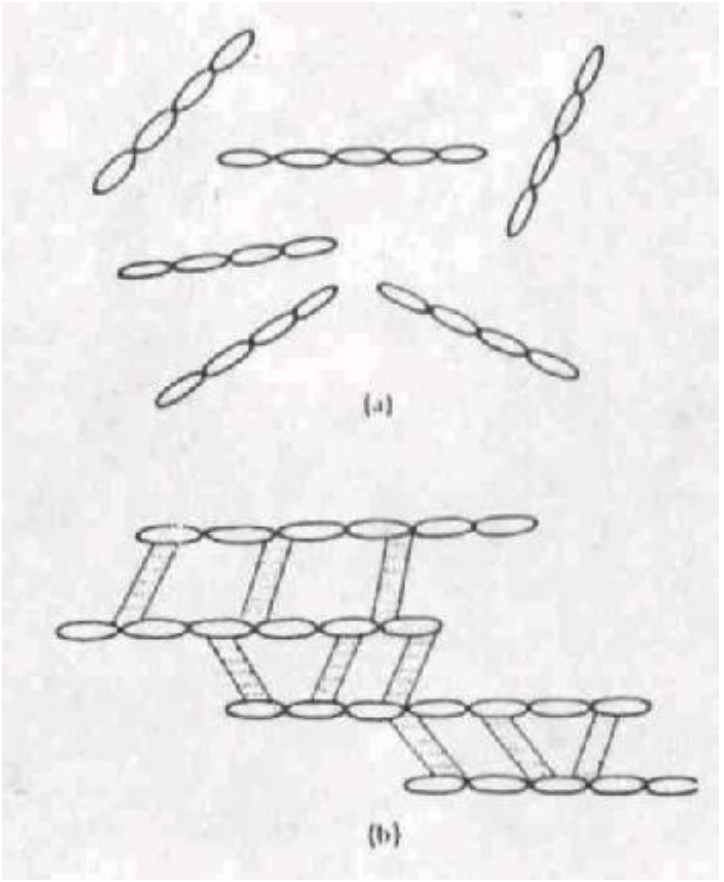
Synthetic Fibers

1. Polymers – virtually infinite, end-to-end linked monomer units (-A-A-Apattern, where –A- represents the monomer).

2. Copolymers – consist of two different monomers linked in a virtually infinite, end-to-end arrangement (-A-B-A-B- pattern, where –A- and –B- represent two different monomers).

Synthetic Fibers

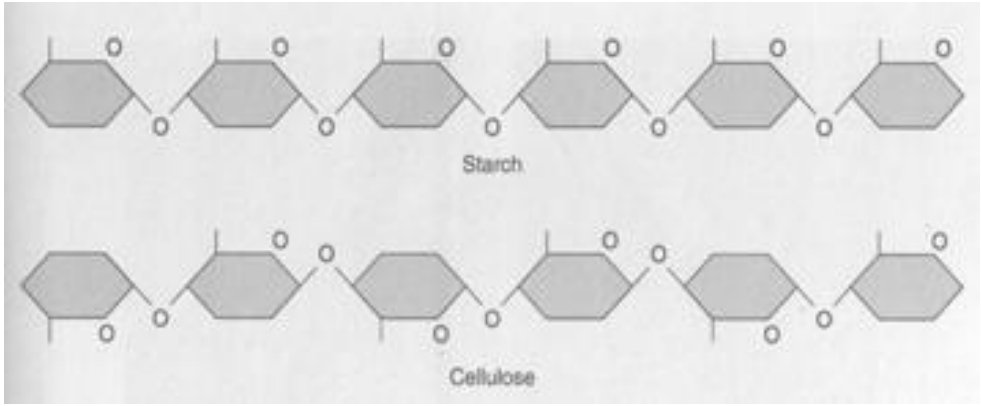
- Cross-linked polymers:
  - parallel chains are chemically linked to one-another.
  - adds rigidity and inflexibility.



Important Synthetic Fibers

Regenerated Fibers: made from chemically altering a natural polymer (cellulose).

- Rayon
- Acetate
- Triacetate



Synthetic Fibers Examples

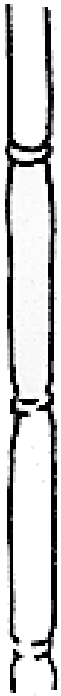
Synthetic polymers and copolymers

- Acrylic
- Aramid
- Bicomponent
- Lyocel
- Melamine
- Modacrylic
- Nylon
- Olefin
- Polyester
- PBI/PBF
- Spandex

Fibers

Cotton

Wool



Linen

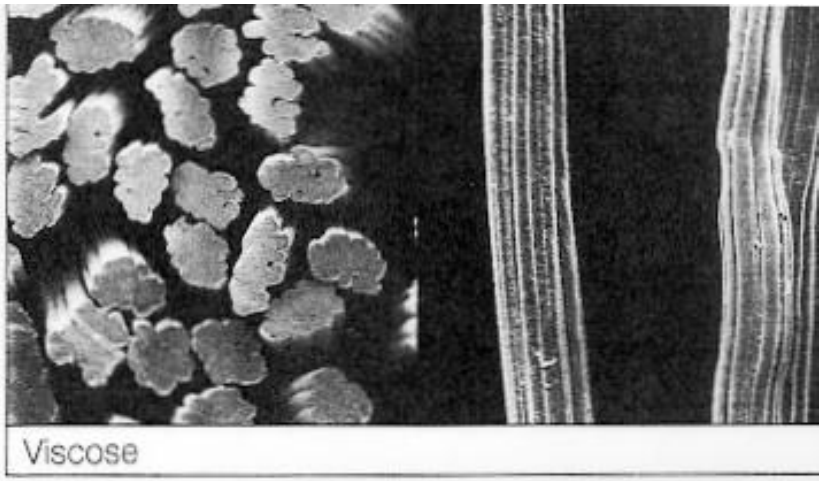
Nylon

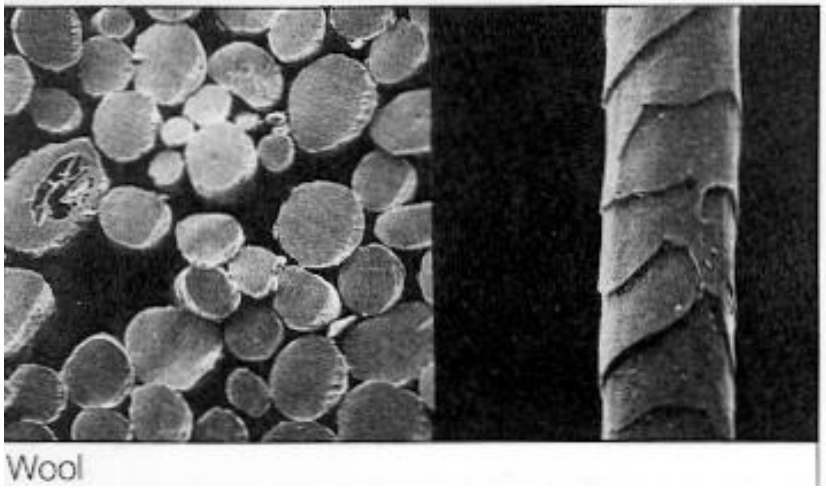
Silk

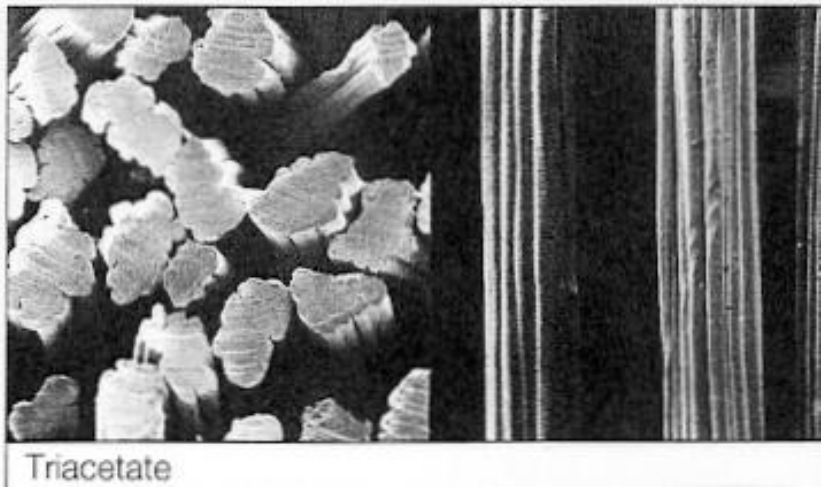
Rayon

Fibers

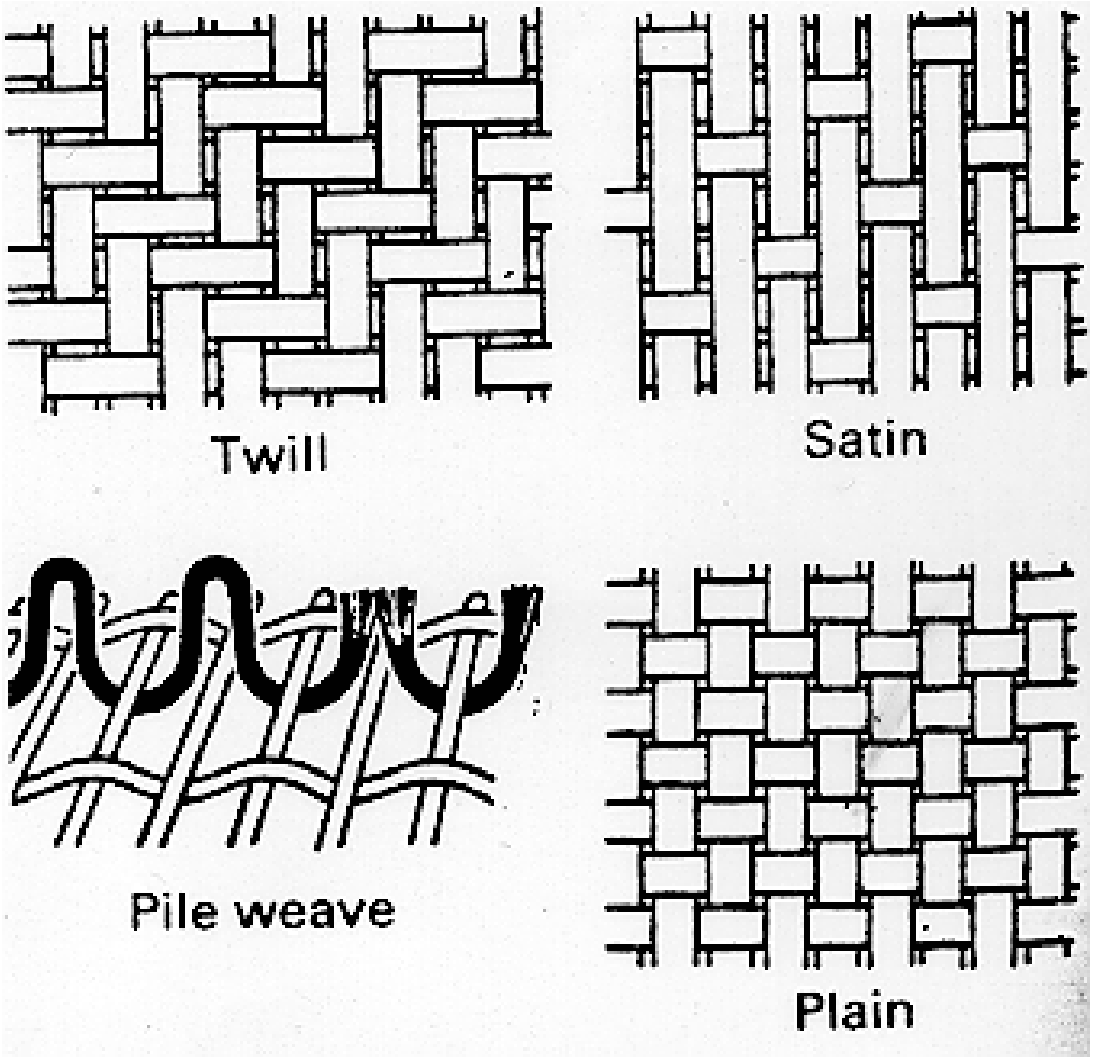

Cotton


Viscose


Wool


Triacetate

Cloth from Fibers



Fiber Cross-Sectional Shape

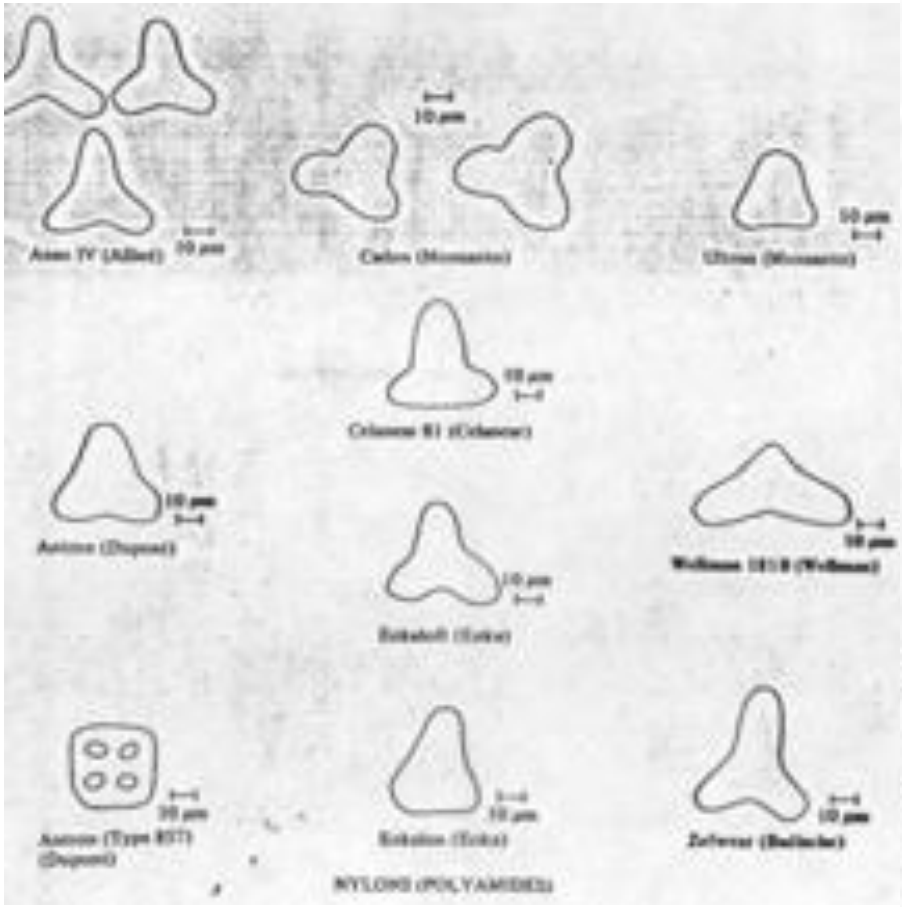


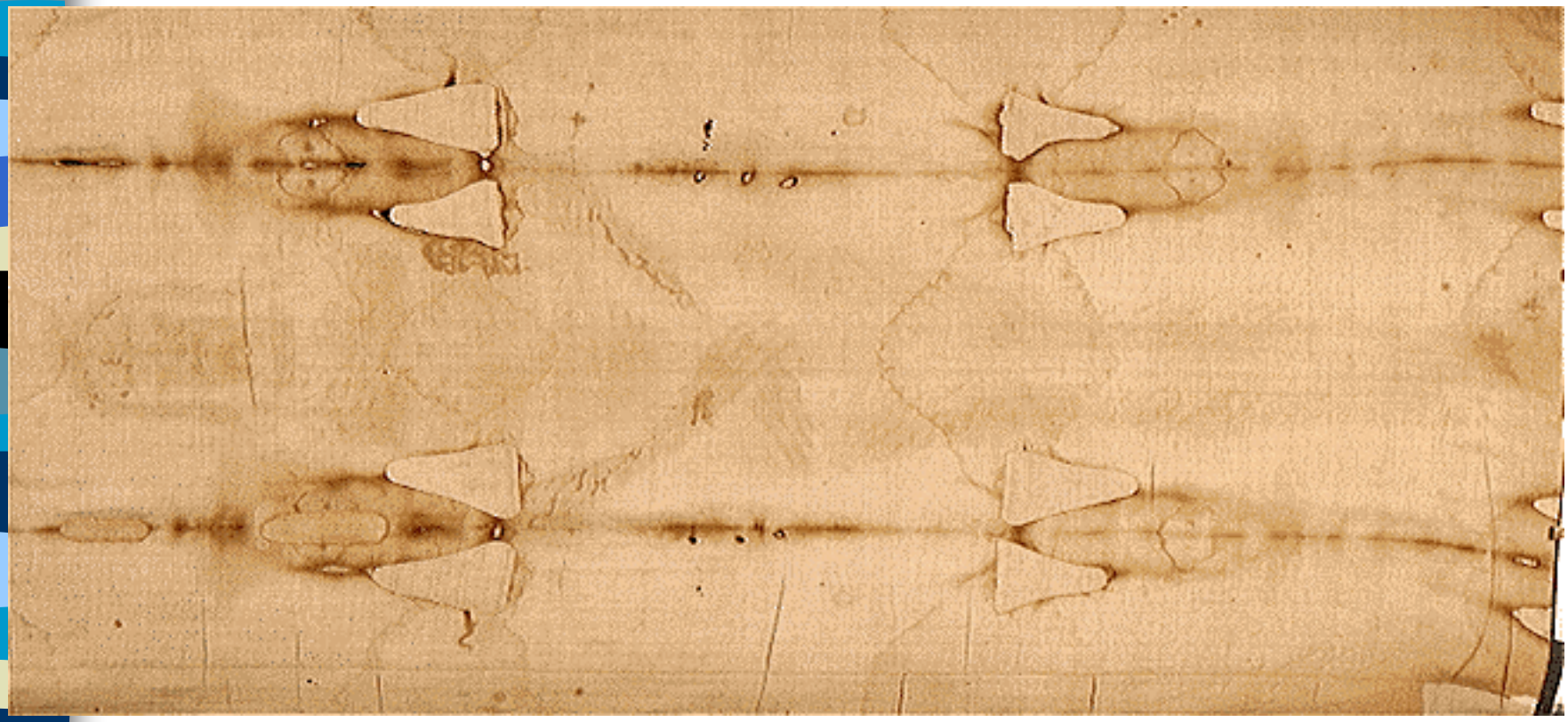
FIGURE 8–13 A scanning electron photomicrograph of the cross section of a nylon fiber removed from a sheet used to transport the body of a murder victim. The fiber, associated with a carpet in Wayne Williams's home, was manufactured in 1971 in relatively small quantities. *Courtesy Federal Bureau of Investigation, Washington, D.C.*

Shroud of Turin - Fiber Analysis

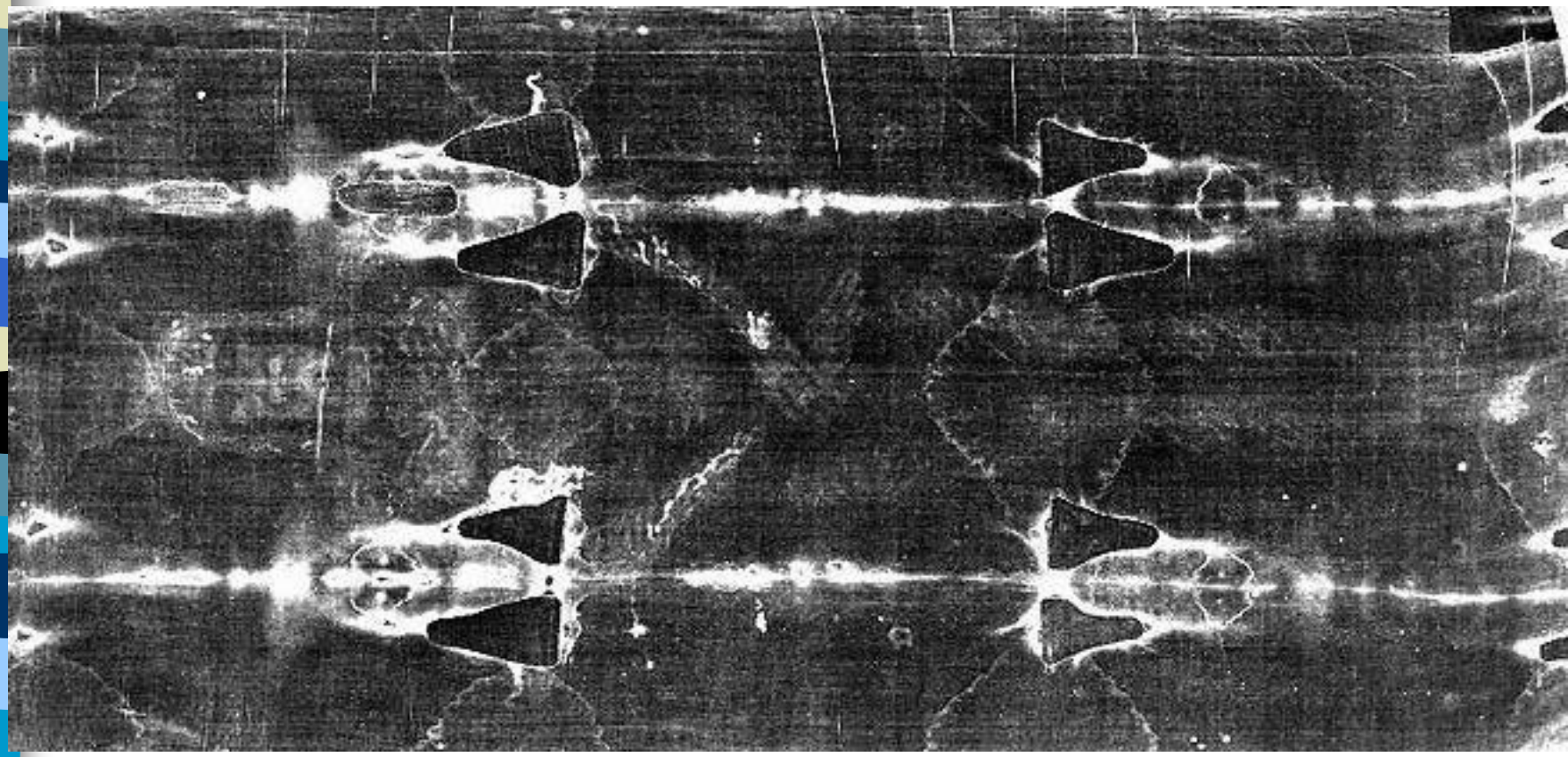
Cathedral of St. John the Baptist, Turin
Home of the Shroud of Turin

Shroud of Turin - Fiber Analysis

Shroud of Turin - Fiber Analysis



Shroud of Turin - Fiber Analysis



A Forensic Nightmare?

Shroud of Turin - Fiber Analysis

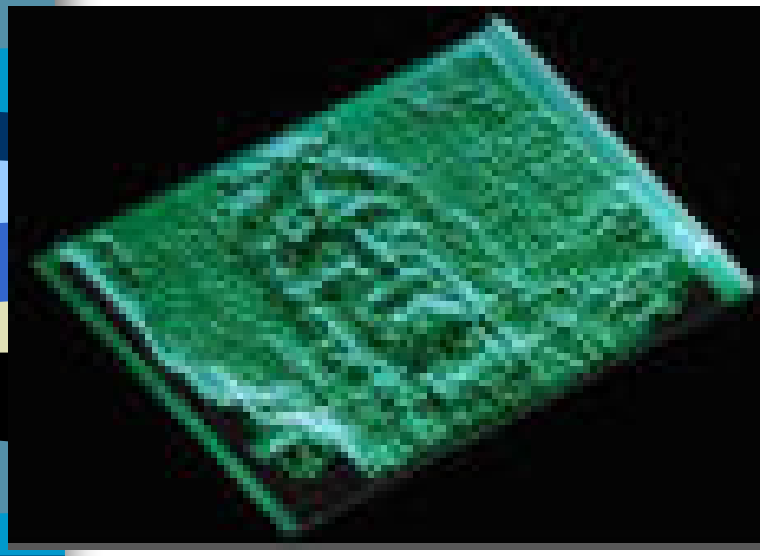
The weave of the Shroud of Turin is rich and gold colored under high magnification of a microscope.

http://www.shroudstory.com/

http://biblia.com/jesusart/turin.htm

http://www.world-mysteries.com/sar_2.htm

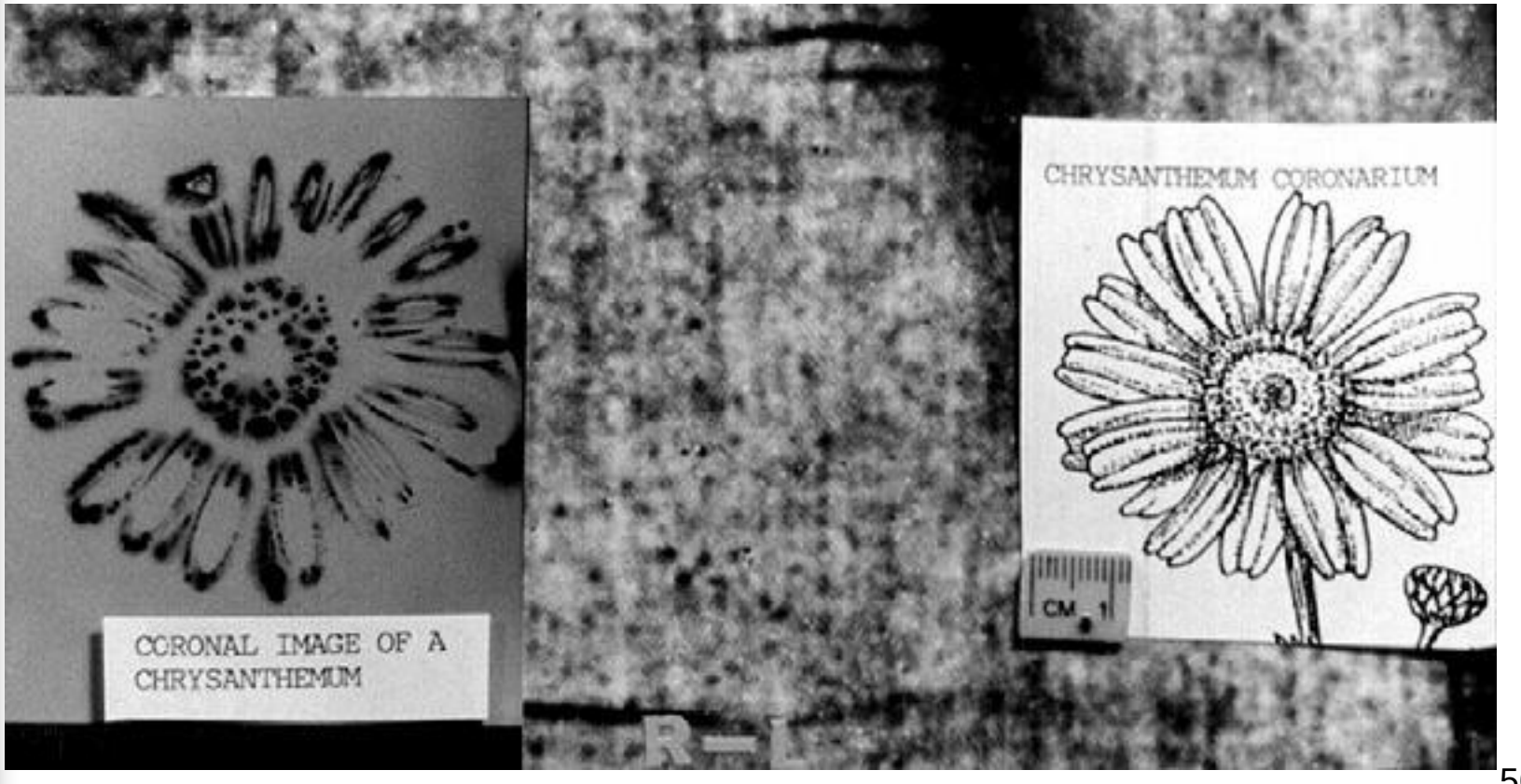
Shroud of Turin - Fiber Analysis



Blood or Paint?

Shroud of Turin - Fiber Analysis

Pollen Analysis

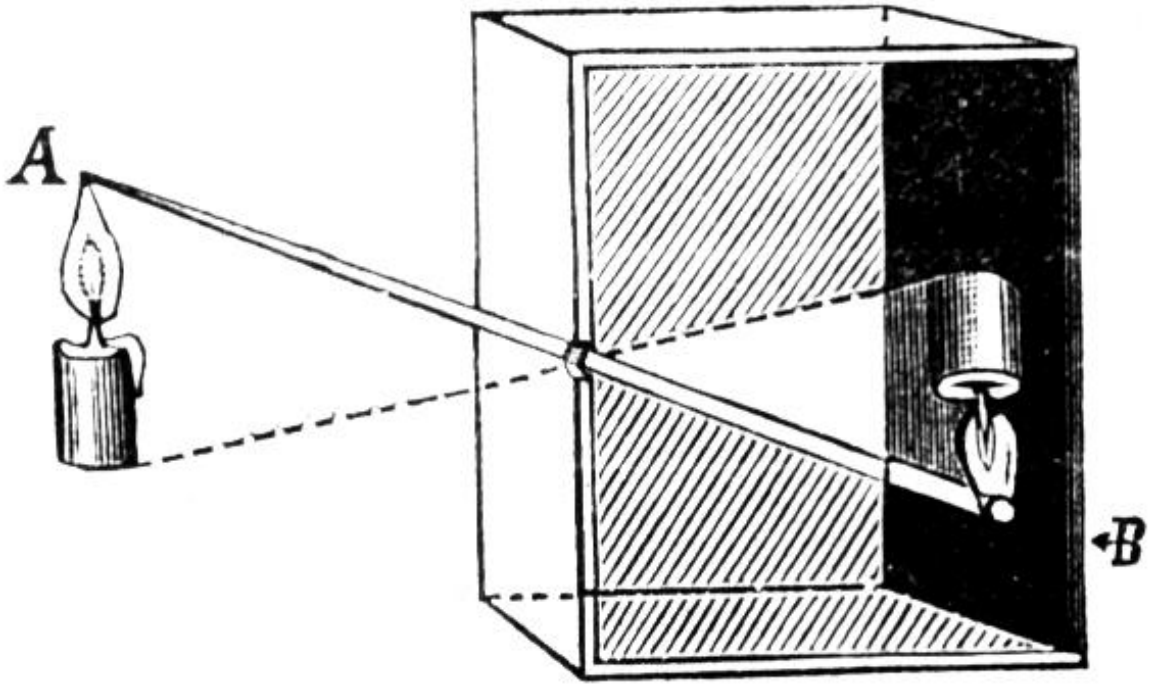


Sudarium of Oviedo

One of the relics held by the cathedral in the town of Oviedo, in the north of Spain, is a piece of cloth measuring approximately 84 x 53 cm. There is no image on this cloth. Only stains are visible to the naked eye, although more is visible under the microscope. The remarkable thing about this cloth is that both tradition and scientific studies claim that the cloth was used to cover and clean the face of Jesus after the crucifixion.

Leonardo DaVinci

Pin-Hole Camera



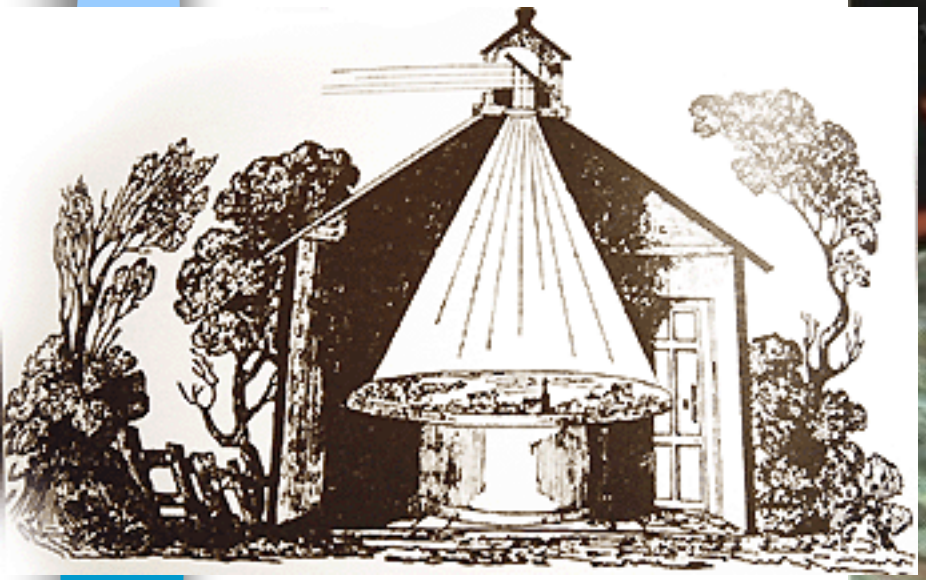
MR. GALPIN'S

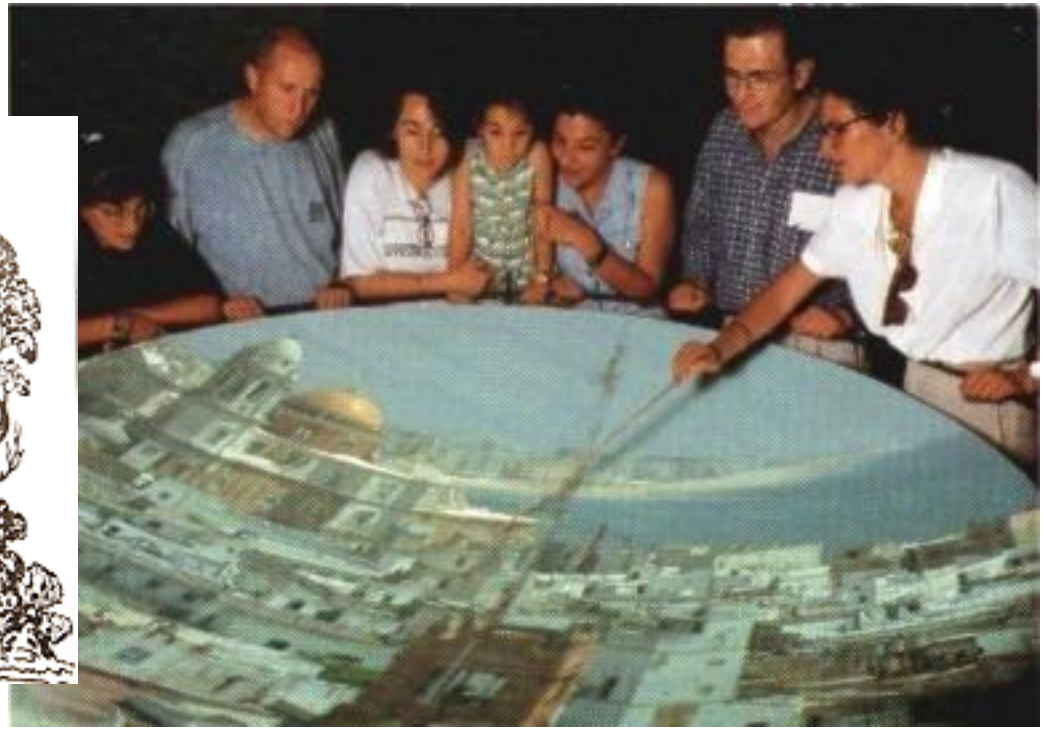
CAMERA OBSCURA.

IN consequence of the great success of Mr. Galpin's Camera, and the large amount of time taken up in showing visitors, the Messrs. Galpin have decided to charge One Shilling (1s.) each to all who may wish to see this most striking and entertaining Panorama of Grahamstown.

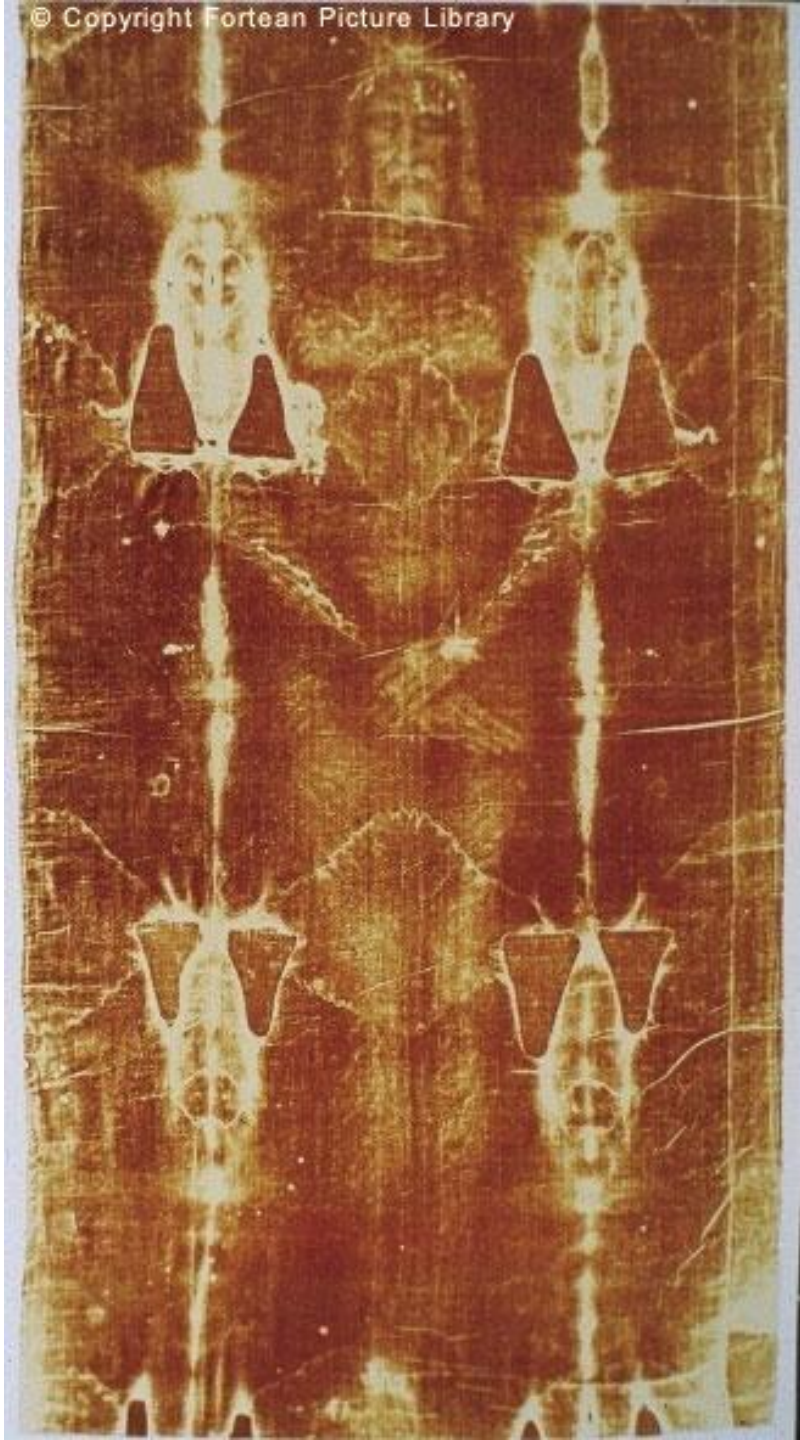
Without the aid of advertisement, and solely through its great beauty, this Camera has become known throughout the whole Colony, and has afforded much delight and entertainment to thousands of people. 11/2

Camera Obscura

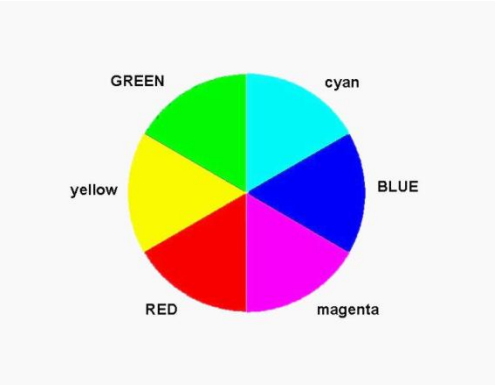




Camera Obscura



Paint Evidence



What is Paint?

- Colloidal Suspension 3 parts (emulsions):
  - pigment - particles of a colored compound
  - medium - suspends the pigment particles and fixes them to the surface
  - volatile liquid - allows control over the consistency of the paint

- Paint colors
  - pigments - compound that is suspended in a medium that is bound to a surface; insoluble in the "vehicle"
  - dye -binds to the surface itself; soluble

  (paints have both pigments and a vehicle while cloth might be dyed with a compound that binds itself to the surface of the fibers)

Automobile "Finishes"

The automotive finishing system for steel involves at least four organic coatings:

- **Electrocoat primer – black to gray** electrodeposited epoxy resin.

- **Primer surfacer – highly pigmented, gray to red**

- **Basecoat – the "colorcoat,"** an acrylic-based polymer coating that contains pigments and may contain additives to achieve desirable finish effects

- **Clearcoat** – acrylic or polyurethane-based, clear topcoat

"Individualizing" Class Evidence

- Subtle differences in the finishes of cars from manufacturer to manufacturer may make it possible to "individualize" paint evidence

- The "customizing" of an automobile's finish to a customer's specifications may make it surprisingly "individual."

- Lacking sufficient complexity in its layer structure or shape, a paint chip can only be associated with a "class" of items,

Paint Chip Analysis

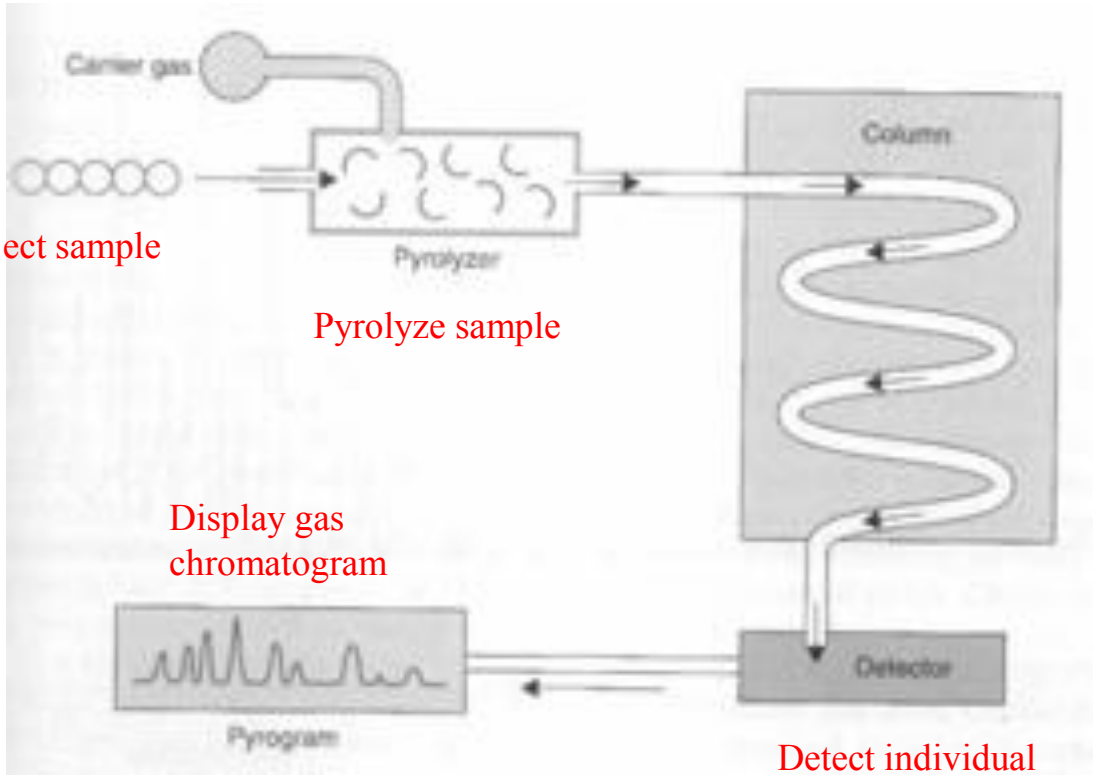
1. Microscopic examination for gross and fine details, such as color and layer structure.

2. Microspectrophotometry for identification of the colors of individual paint layers.

3. Pyrolysis gas chromatography for identification of the resin binder.

4. Atomic emission spectroscopy

Pyrolysis Gas Chromatography



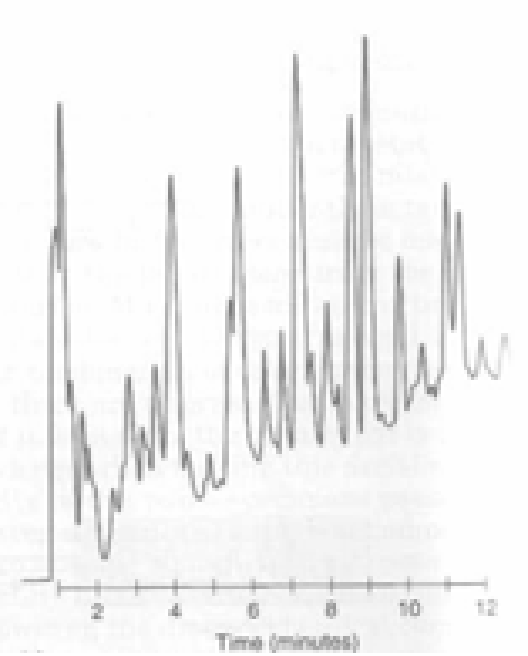
Inject sample

Pyrolyze sample

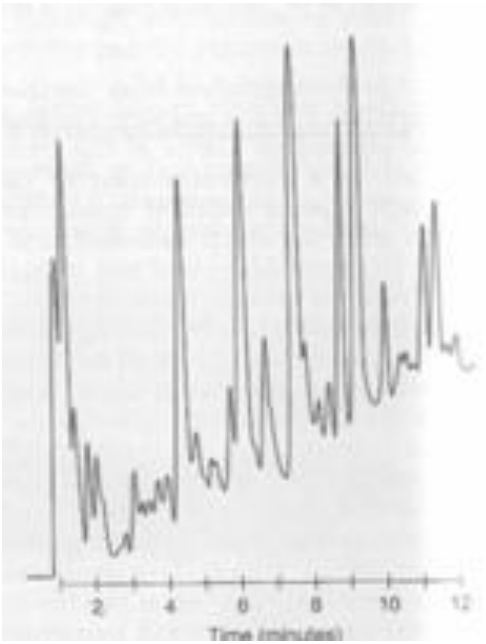
Separate pyrolysis products

Display gas chromatogram

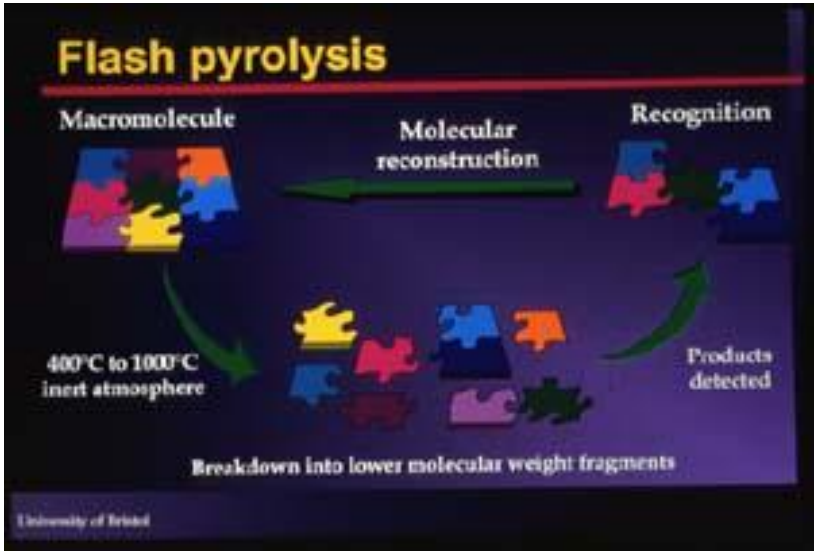
Detect individual pyrolysis products



Paint from a Ford model



Paint from a Chrysler model



Paint Data Query: PDQ

• Contains the chemical compositions of paint from the majority of vehicles marketed in North America after 1973.

How does PDQ work?

1. Each paint layer is examined to determine the composition.
2. The chemical components and proportions are coded into the database.
3. These known samples are compared against a paint sample from a crime scene or a suspect's vehicle to search the make, model, and year of a vehicle involved in a hit-and-run or other criminal activity.