Chapter 2

Types of Evidence

"You can observe a lot just by watching."

—Yogi Berra, former New York Yankees catcher and sage

Photos from Kendall Hunt Publishing

Content from various chapters in Forensic Science for High School Students and numerous other sources

Classification of Evidence

Testimonial evidence is a statement made under oath; also known as direct evidence or *prima facie* evidence.

Physical evidence is any object or material that is relevant in a crime; also known as indirect evidence. Examples are hair, fiber, fingerprints, documents, blood, soil, drugs, toolmarks, impressions, glass.

Reliability of Eyewitness

Factors that affect accuracy:

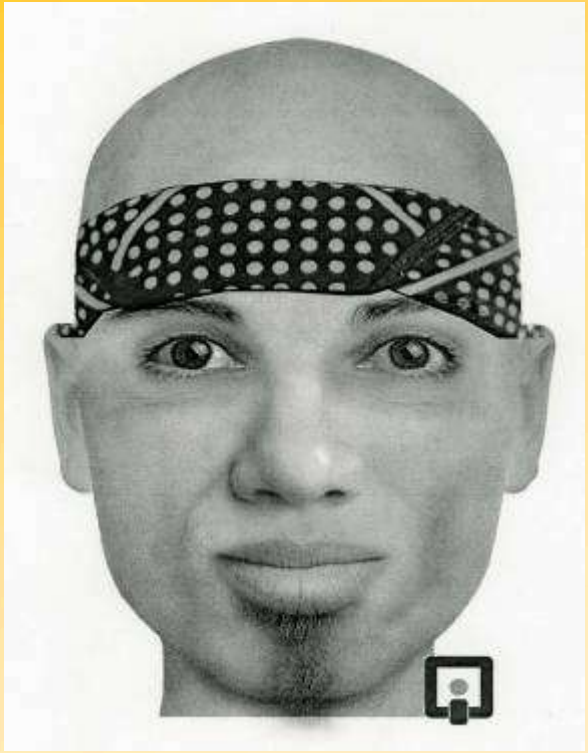
- Nature of the offense and the situation in which the crime is observed
- Characteristics of the witness
- Manner in which the information is retrieved

Additional factors:

- Witness's prior relationship with the accused
- Length of time between the offense and the identification
- Any prior identification or failure to identify the defendant
- Any prior identification of a person other than the defendant by the eyewitness

Eyewitness

A police composite may be developed from the witness testimony by a computer program or forensic artist.



FACES—a composite program by InterQuest

Physical Evidence

As a result of the influences on eyewitness memory, physical evidence becomes critical.

Is generally more reliable than testimonial evidence

Can prove that a crime has been committed

Can corroborate or refute testimony

Can link a suspect with a victim or with a crime scene

Can establish the identity of persons associated with a crime

Can allow reconstruction of events of a crime

Reconstruction

Physical evidence can be used to answer questions about:

- What took place at a crime scene
- The number of people involved
- The sequence of events

A forensic scientist compares the *questioned* or unknown sample from the crime scene with a sample of *known* origin.

Types of Physical Evidence

Transient evidence is temporary; easily changed or lost; usually observed by the first officer at the scene.

Pattern evidence is produced by direct contact between a person and an object or between two objects.

Conditional evidence is produced by a specific event or action; important in crime scene reconstruction and in determining the set of circumstances or sequence within a particular event.

Transfer evidence is produced by contact between person(s) and object(s), or between person(s) and person(s).

Associative evidence is something that may associate a victim or suspect with a scene or with each other; e.g., personal belongings.

—Henry C. Lee and Jerry Labriola, *Famous Crimes Revisited,* 2001

Examples of Transient Evidence

Odor—putrefaction, perfume, gasoline, urine, burning, explosives, cigarette or cigar smoke

Temperature—surroundings, car hood, coffee, water in a bathtub, cadaver

Imprints and indentations— footprints, teeth marks in perishable foods, tire marks on certain surfaces

Examples of Pattern Evidence

Pattern evidence—mostly in the form of imprints, indentations, striations, markings, fractures, or deposits

Blood spatter
Glass fracture
Fire burn pattern
Furniture position
Projectile trajectory
Tire marks or skid marks

Clothing or article distribution
Gunpowder residue
Material damage
Body position
Toolmarks
Modus operandi

Examples of Conditional Evidence

Light—headlight, lighting conditions, lights on or off

Smoke—color, direction of travel, density, odor

Fire—color and direction of the flames, speed of spread, temperature and condition of fire

Location—of injuries or wounds, of bloodstains, of the victim's vehicle, of weapons or cartridge cases, of broken glass

Vehicles—doors locked or unlocked, windows opened or closed, radio off or on, odometer mileage

Body—position and types of wounds; rigor, livor, and algor mortis

Scene—condition of furniture, doors and windows, any disturbance or signs of a struggle

Classification of Evidence by Nature

Biological—blood, semen, saliva, sweat, tears, hair, bone, tissues, urine, feces, animal material, insects, bacteria, fungi, botanical material

Chemical—fibers, glass, soil, gunpowder, metals, minerals, narcotics, drugs, paper, ink, cosmetics, paint, plastic, lubricants, fertilizer

Physical—fingerprints, footprints, shoeprints, handwriting, firearms, tire marks, toolmarks, typewriting

Miscellaneous—laundry marks, voice analysis, polygraph, photography, stress evaluation, psycholinguistic analysis, vehicle identification

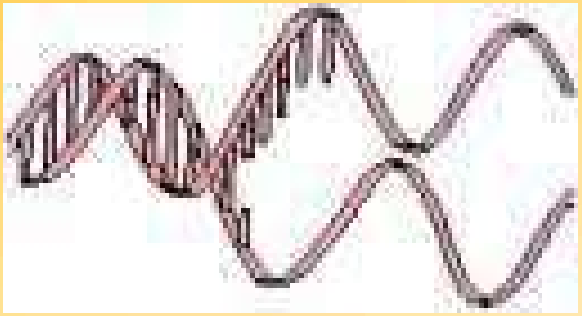
Evidence Characteristics

Individual—can be identified with a particular person or a single source

- **Fingerprints - 1 X 10^{60}**
  - 1 in 1,000,000,000,000,000,000,000,000,000,000,000,000,000,000,000,000,000,000,000,000,000

Fingerprints

Blood DNA Typing



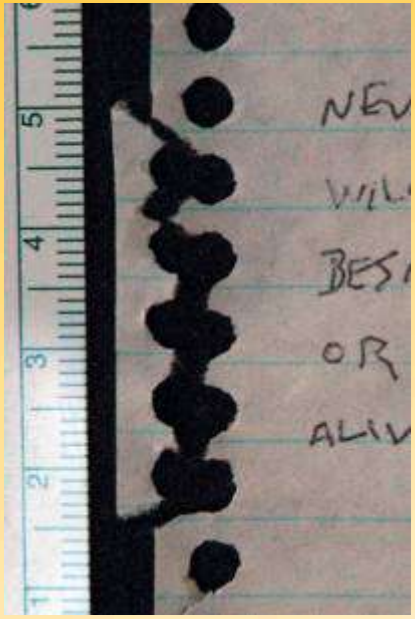
Class—common to a group of objects or persons

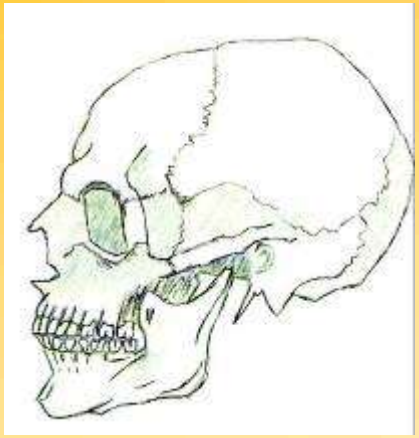
Class vs. Individual Evidence

These fibers are class evidence; there is no way to determine if they came from this garment.

The large piece of glass fits exactly to the bottle; it is individual evidence.

Class vs. Individual Evidence, *continued*





Which examples do you think could be individual evidence?

Forensic Investigations

Include some or all of these seven major activities:

- **Recognition**—the ability to distinguish important evidence from unrelated material
  - Pattern recognition
  - Physical property observation
  - Information analysis
  - Field testing
- **Preservation** through the collection and proper packaging of evidence

Forensic Investigations, *continued*

- **Identification** using scientific testing
  - Physical properties
  - Chemical properties
  - Morphological (structural) properties
  - Biological properties
  - Immunological properties
- **Comparison** of class characteristics measured against those of known standards or controls; if all measurements are equal, then the two samples may be considered to have come from the same source or origin

Forensic Investigations, *continued*

â **Individualization** in demonstrating that the sample is unique, even among members of the same class

â **Interpretation**—giving meaning to all the information

7. Reconstruction of the events in the case

Inductive and deductive logic

Statistical data

Pattern analysis

Results of laboratory analysis

—Henry C. Lee and Jerry Labriola, *Famous Crimes Revisited*, **2001**

Collecting Trace Evidence

Who collects the evidence?

- Police Officer
- Crime Scene Investigator
- Forensic Scientist

Depends on the state/community

Often **one person** to ensure consistency of labeling

Collect trace or entire object?

Suppose a glove appears to have glass, fibers and blood on it.

Should the glass, fibers and blood be removed and packaged separately?

Should the entire glove be packaged?

Considerations before packaging entire object:

- Object may be too large or difficult to move
- Trace evidence may fall off item during transport.
- Trace Evidence may be transferred to different, irrelevant area of object.

If packaging object, **package objects separately.**

Prevents trace being transferred to other objects.

These 3 methods can be done at the crime scene or in the crime lab.

1. Visual Inspection
2. Tape Lift
3. Vacuum

Visible Inspection

- Use naked eye or hand lens.
- Evidence removed and packaged for later analysis
- Use bright light and forceps to collect.

Visible Inspection (Packaging)

- Small paper envelopes are bad (Holes allow small objects to escape).
- Use small plastic bags, glass vial or paper using a druggist fold.
- Double package. Label each package.

Tape Lift

- Clear tape is used.
- Repeatedly apply tape to small area until most of the stickiness is gone.
- Tape is folded back upon itself, taped to a glass slide or taped to a piece of plastic.
- Put in separate labeled container.

  Be sure to document specific area covered.

Vacuuming

- Nozzle should be short and transparent.
- Debris is collected on a filter or membrane

Vacuuming

- Small area is vacuumed. (Filters changed frequently)
- Filters packaged in separate labeled container. (Be sure to document specific area covered)
- **Most improperly used method** because it often results in the collection of a lot of irrelevant material.

Druggist Fold

- Consists of folding one end of the paper over one third, then folding the other end one third over that, and repeating the process from the other two sides.
- After the paper is folded in this manner, the outside two edges are tucked into each other to produce a closed container that keeps specimen from falling out.

Wayne Williams Trial

- Fulton County Case in 1981
- First case in which primary evidence was fiber evidence
- Fibers linked Williams to being in contact with the bodies
- Media released info that GBI/FBI were collecting fibers
- Williams began dumping nude bodies in rivers

Wayne Williams Trial

- Fiber links to dog, cars, home, bedspread
- He was convicted for being linked to the bodies prior to dumping
- Set standard for murder trials based on overwhelming circumstantial evidence

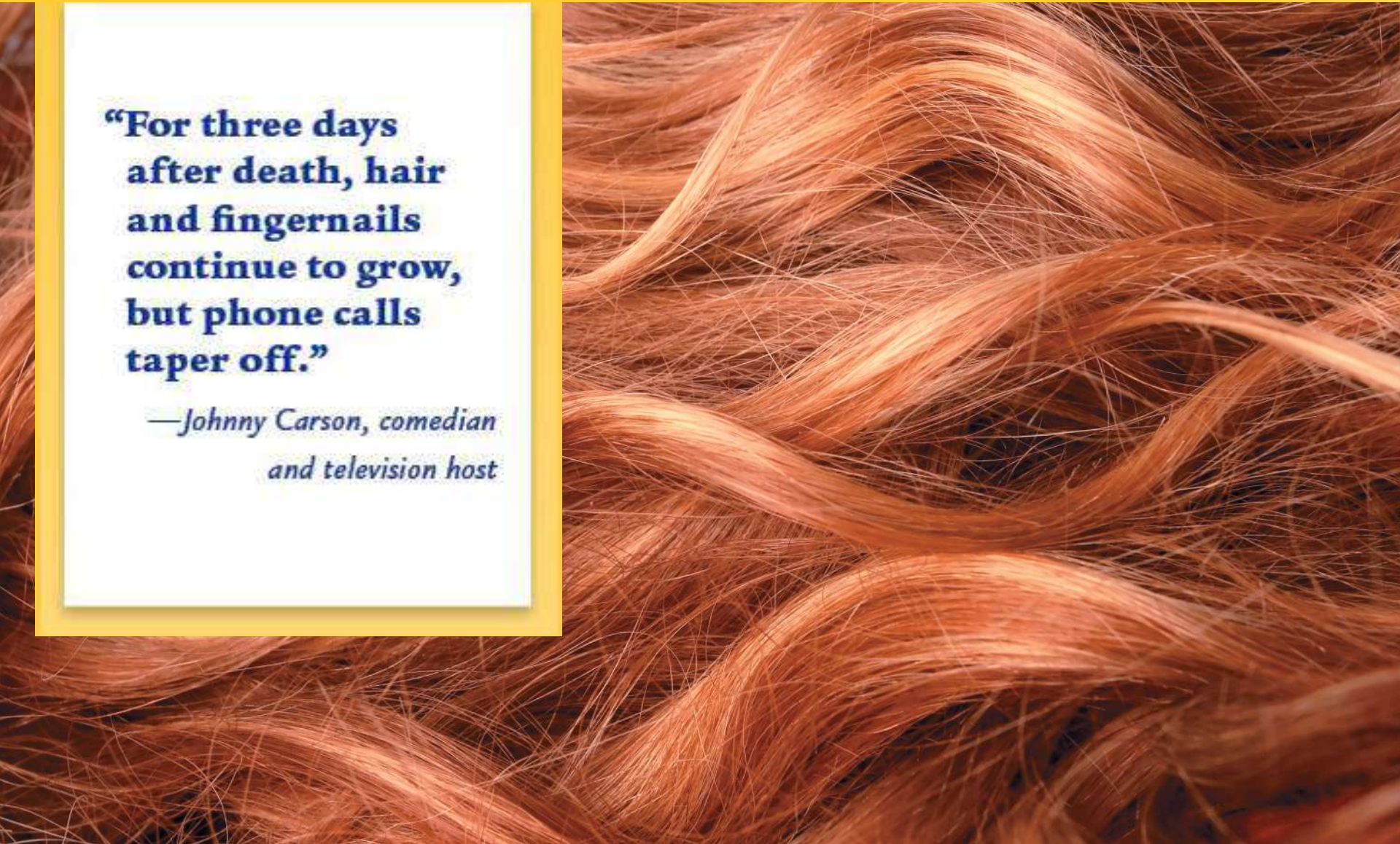
Chapter 5

Hair

Hair

"For three days after death, hair and fingernails continue to grow, but phone calls taper off."

—Johnny Carson, comedian and television host



Introduction

Human hair is one of the most frequently found pieces of evidence at the scene of a violent crime. It can provide a link between the criminal and the crime.

From hair, one can determine:

If the source is human or animal

Race (sometimes)

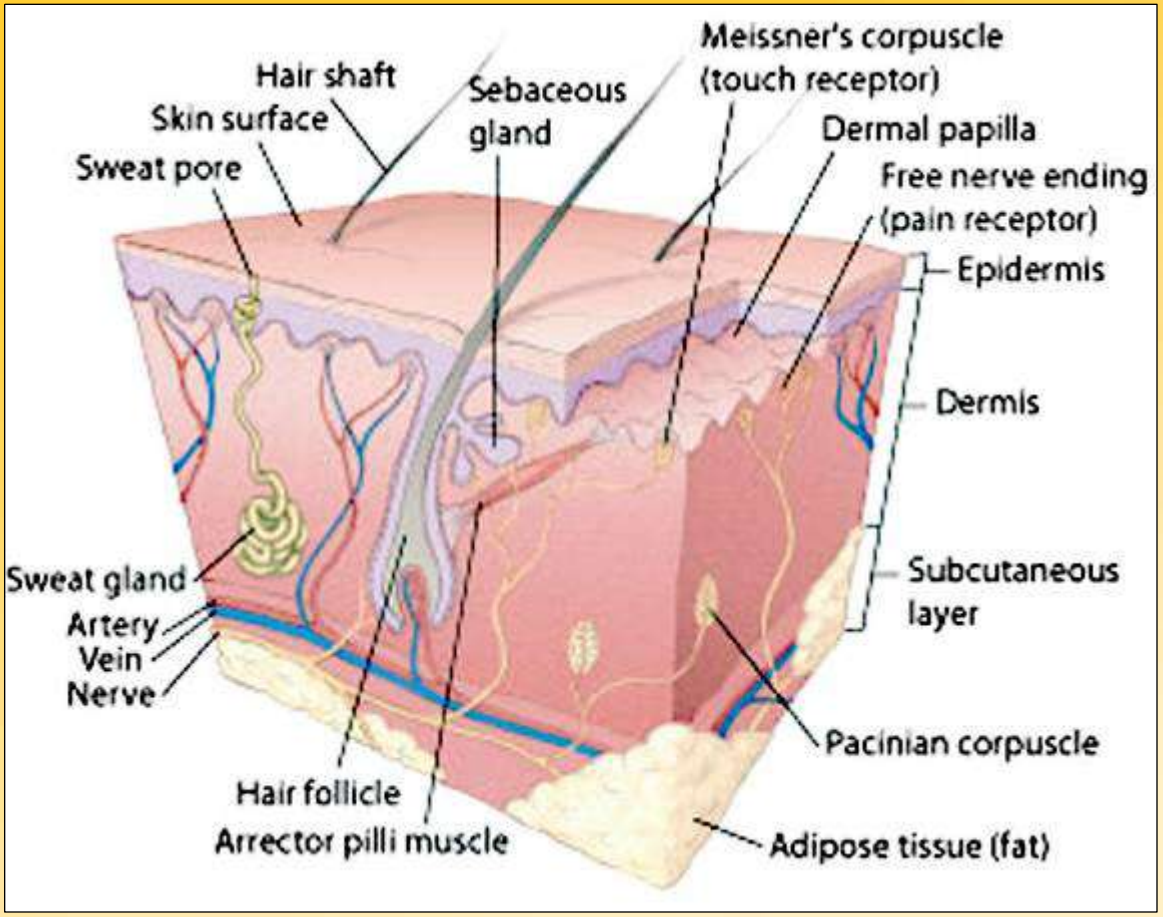
Origin of the location on the source's body

Whether the hair was forcibly removed

If the hair has been treated with chemicals

If drugs have been ingested

Skin Structure



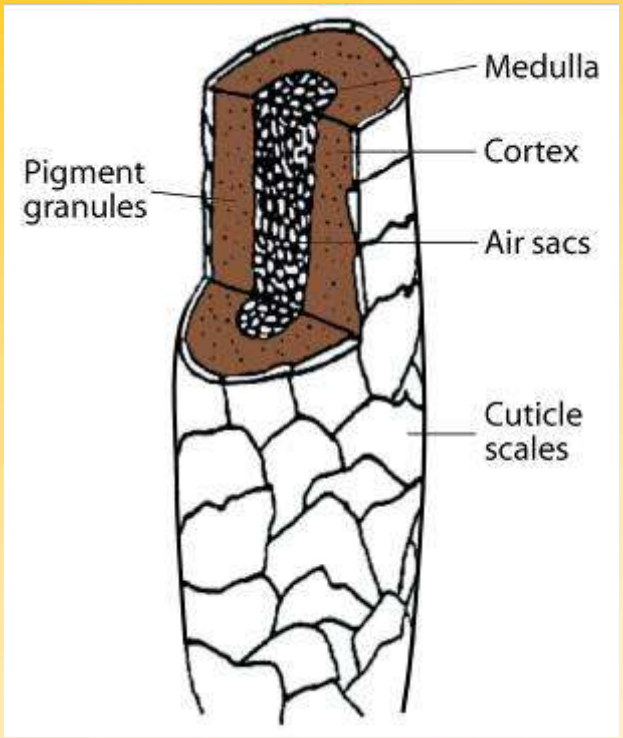
Hair Shaft

Composed of:

Cuticle—outside covering, made of overlapping scales

Cortex—inner layer made of keratin and embedded with pigment; also contains air sacs called cortical fusi

Medulla—inside layer running down the center of the cortex



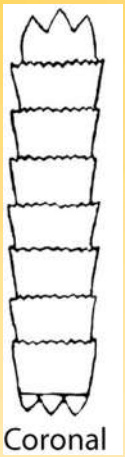
The Cuticle

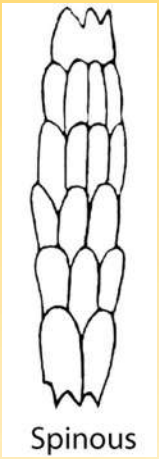
The cuticle is the outermost layer of hair which is covered with scales. The scales point toward the tip of the hair. Scales differ among species of animals and are named based on their appearance. ***The three basic patterns are:***

Coronal

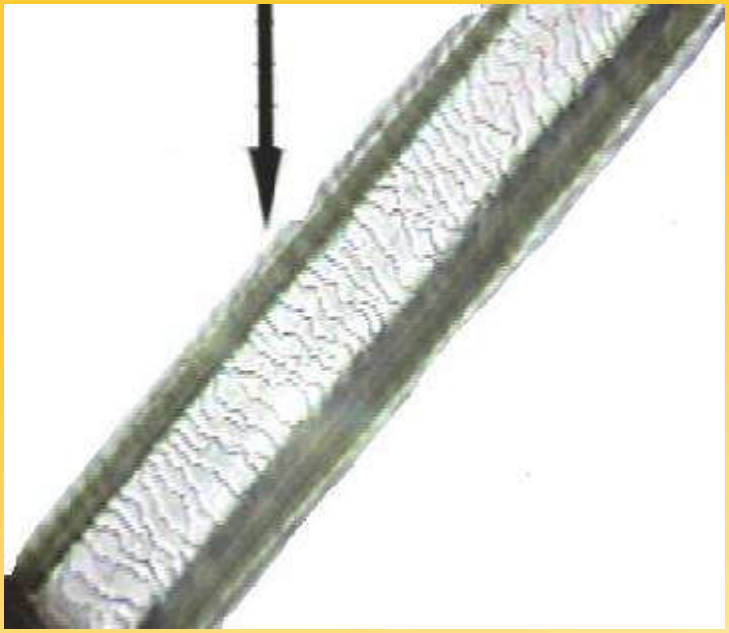
Spinous

Imbricate





Human Scales



In order to visualize the scales:

Paint clear fingernail polish on a glass slide.

When the polish begins to dry, place a hair on the polish.

When it is almost dry, lift off the hair and observe the scale imprints.

What pattern is seen in this slide?

The Cortex

The cortex gives the hair its shape.

It has two major characteristics:

Melanin—pigment granules that give hair its color

Cortical fusi—air spaces, usually found near the root but may be found throughout the hair shaft

The Medulla

The medulla is the hair core that is not always visible. The medulla comes in different types and patterns.

Types:

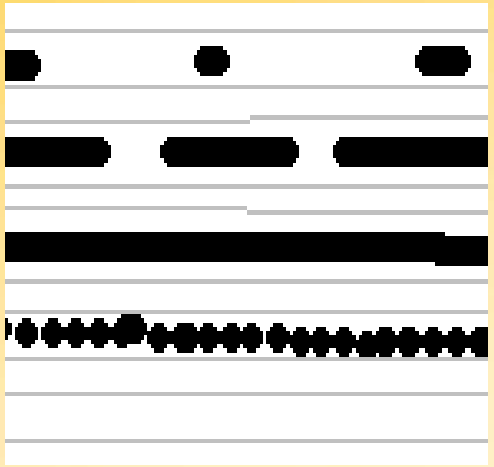
Intermittent or interrupted

Fragmented

Continuous

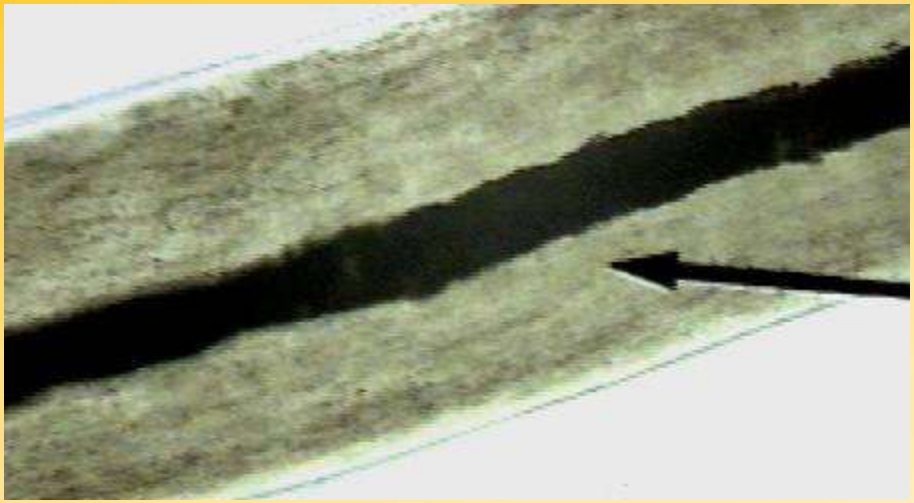
Stacked

Absent—not present



Human Medulla

Human medulla may be continuous, fragmented, or absent.



Medullary Index

Determined by measuring the diameter of the medulla and dividing it by the diameter of the hair.

Medullary index for human hair is generally less than 1/3.

For animal hair, it is usually greater than 1/2.

Hair Shape

Can be straight, curly, or kinky, depending on the cross-section, which may be round, oval, or crescent-shaped.

Round
(Straight)

Oval
(Curly)

Crescent moon
(Kinky)

Hair Growth

Terminology

Anagen—hair is actively growing; lasts up to 5 years

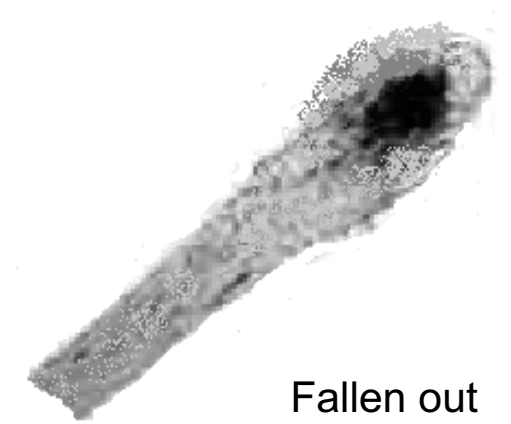
Catagen—hair is not growing; a resting phase

Telogen—follicle is getting ready to push the hair out; lasts two to six months

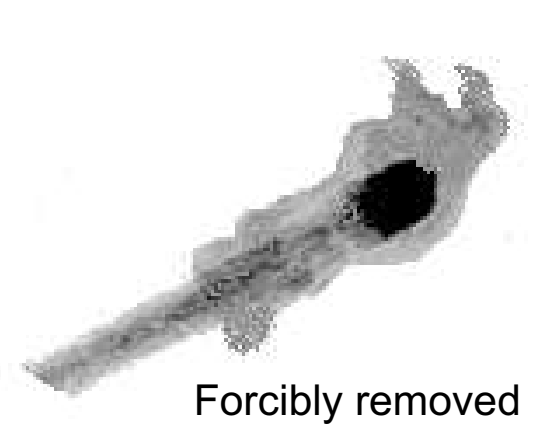
Grows about 0.4 mm per day, or 1 cm per month; approximately one-half inch per month

The Root

Human roots look different based on whether they have been forcibly removed or they are telogen hairs and have fallen out. Animal roots vary, but in general have a spear shape.



Fallen out



Forcibly removed

Hair Comparison

Color

Length

Diameter

Distribution, shape, and color intensity of pigment granules

- Dyed hair has color in cuticle and cortex
- Bleaching removes pigment and gives a yellow tint

Scale types

Presence or absence of medulla

Medullary type

Medullary pattern

Medullary index

DNA from Hair

The root contains nuclear DNA. If the hair has been forcibly removed, some follicular tissue containing DNA may be attached.

The hair shaft contains abundant mitochondrial DNA, inherited only from the mother. It can be typed by comparing relatives if no DNA from the body is available. This process is more difficult and more costly than using nuclear DNA.

Collection of Hair

Questioned hairs must be accompanied by an adequate number of control samples.

- From victim
- From possible suspects
- From others who may have deposited hair at the scene

Control sample

- 50 full-length hairs from all areas of scalp
- 24 full-length pubic hairs

Hair Toxicology

Advantages:

- Easy to collect and store
- Is externally available
- Can provide information on the individual's history of drug use or evidence of poisoning

Collections must be taken from different locations on the body to get an accurate timeline.

Hair Toxicology, *continued*

Napoleon died in exile in 1821. By analyzing his hair, some investigators suggest he was poisoned by the deliberate administration of arsenic; others suggest that it was vapors from the dyes in the wallpaper that killed him.

More about Hair

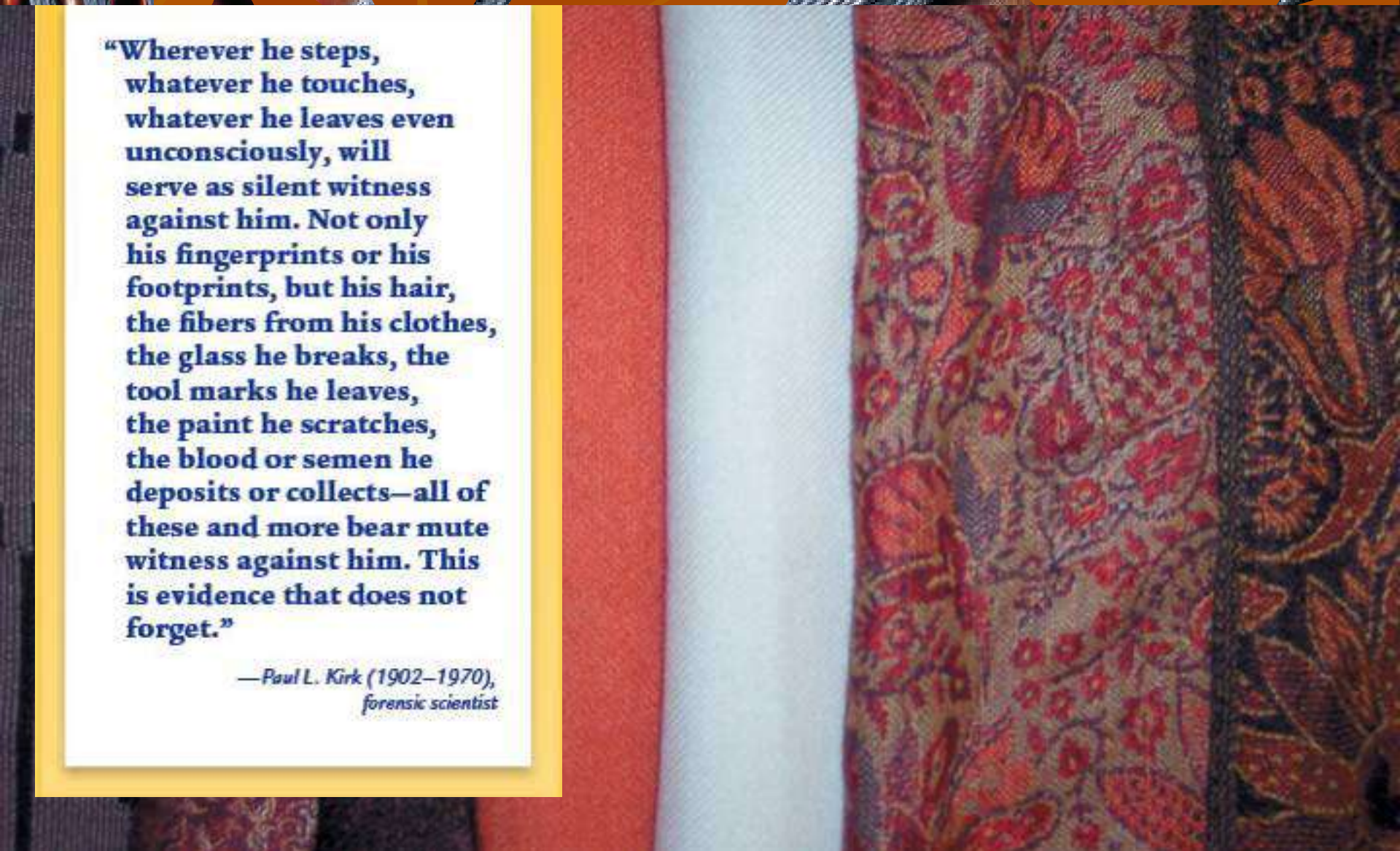
For additional information about hair and other trace evidence, check out truTV's Crime Library at:

www.crimelibrary.com/criminal_mind/forensics/trace/1.html

Fibers

"Wherever he steps, whatever he touches, whatever he leaves even unconsciously, will serve as silent witness against him. Not only his fingerprints or his footprints, but his hair, the fibers from his clothes, the glass he breaks, the tool marks he leaves, the paint he scratches, the blood or semen he deposits or collects—all of these and more bear mute witness against him. This is evidence that does not forget."

—Paul L. Kirk (1902–1970), forensic scientist



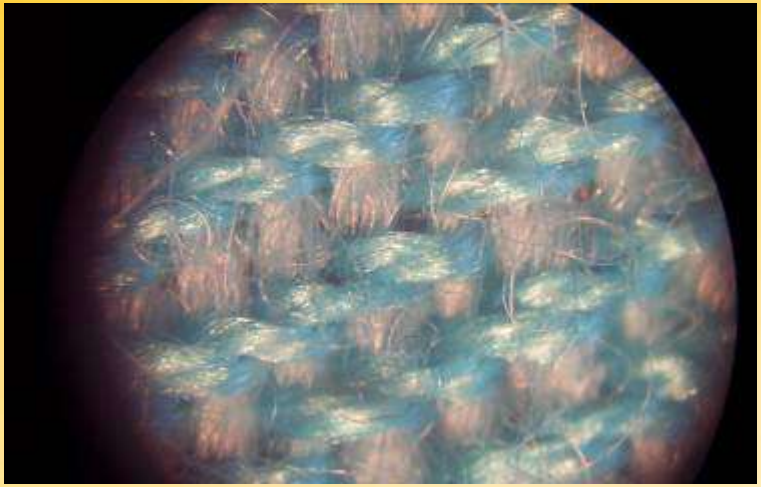
Fibers

Are considered class evidence

Have probative value

Are common trace evidence at a crime scene

Can be characterized based on comparison of both physical and chemical properties



Fabric

Fabric is made of fibers. Fibers are made of twisted filaments.

Types of fibers and fabric:

Natural—animal, vegetable, or inorganic

Artificial—synthesized or

created from altered natural sources

Types of Fibers

Synthetic

Rayon

Nylon

Acetate

Acrylic

Spandex

Polyester

Natural

Silk

Cotton

Wool

Mohair

Cashmere

Classification

Natural fibers are classified according to their origin:

Vegetable or cellulose

Animal or protein

Mineral

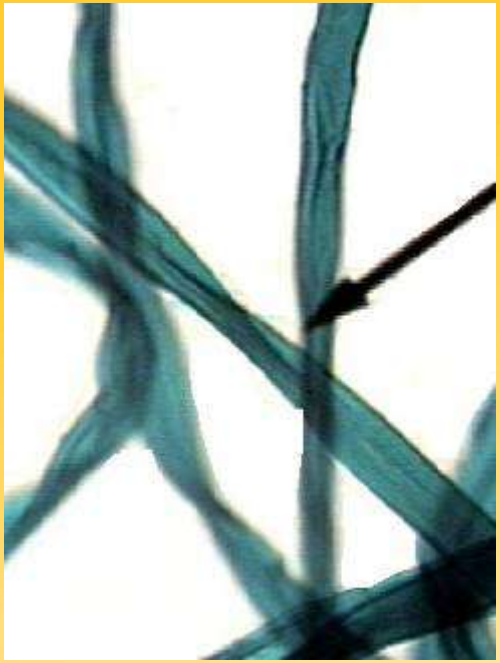
Cellulose Fibers

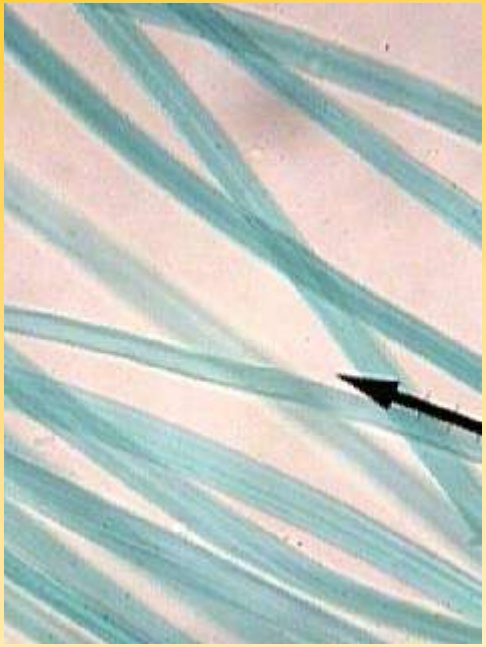
Cotton—vegetable fiber; strong, tough, flexible, moisture-absorbent, not shape-retentive

Rayon—chemically altered cellulose; soft, lustrous, versatile

Cellulose acetate—cellulose that is chemically altered to create an entirely new compound not found in nature

Fiber Comparison





Can you describe the difference(s) between the cotton on the left and the rayon on the right?

Protein Fibers

Wool—animal fiber coming most often from sheep, but may be goat (mohair), rabbit (angora), camel, alpaca, llama, or vicuña

Silk—insect fiber that is spun by a silkworm to make its cocoon; the fiber reflects light and has insulating properties

Mineral Fibers

Asbestos—a natural fiber that has been used in fire-resistant substances

Rock wool—a manufactured mineral fiber

Fiberglass—a manufactured inorganic fiber

Synthetic Fibers

Made from derivatives of petroleum, coal, and natural gas

Nylon—most durable of man-made fibers; extremely lightweight

Polyester—most widely used man-made fiber

Acrylic—provides warmth from a lightweight, soft, and resilient fiber

Spandex—extreme elastic properties

Fabric Production

Fabrics are composed of individual threads or yarns that are made of fibers and are knitted, woven, bonded, crocheted, felted, knotted, or laminated. Most are either woven or knitted. The degree of stretch, absorbency, water repellence, softness, and durability are all individual qualities of the different fabrics.

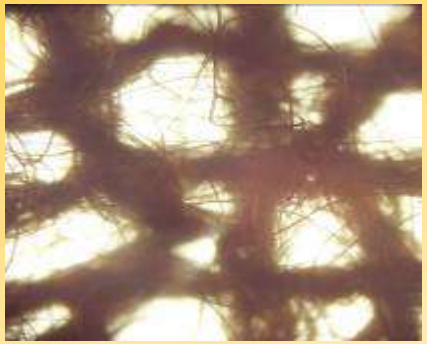
Weave Terminology

Yarn—a continuous strand of fibers or filaments that may be twisted together

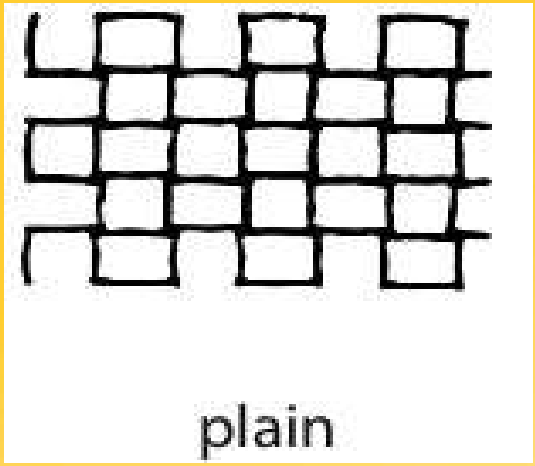
Warp—lengthwise yarn

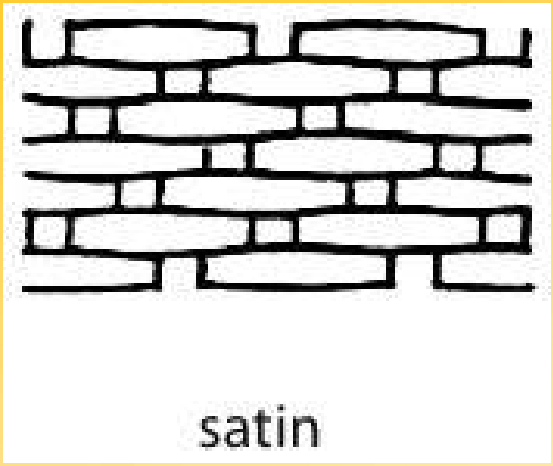
Weft—crosswise yarn

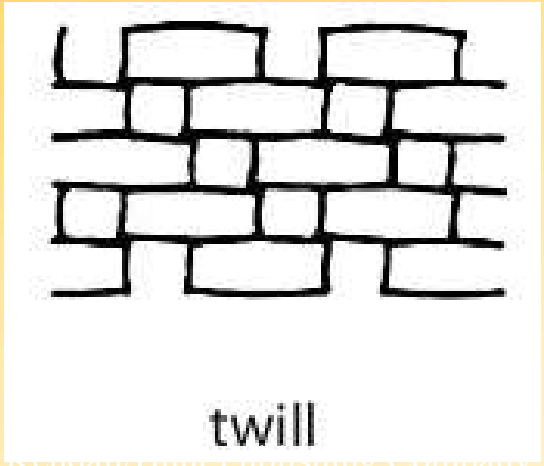
Blend—a fabric made up of two or more different types of fibers



Weave Patterns

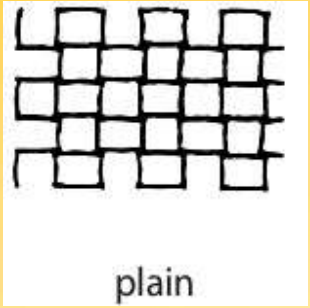






Plain Weave

- The simplest and most common weave pattern
- The warp and weft yarns pass under each other alternately
- Design resembles a checkerboard



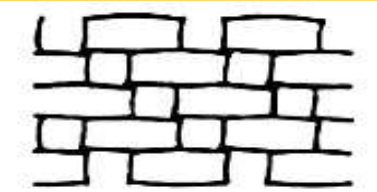
Twill Weave

The warp yarn is passed over one to three weft yarns before going under one.

Makes a diagonal weave pattern.

Design resembles stair steps.

Denim is one of the most common examples.



twill

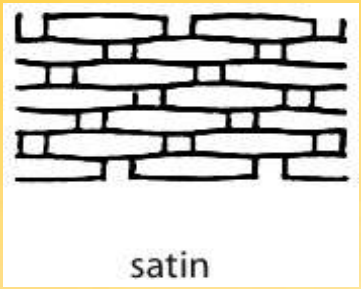
Satin Weave

The yarn interlacing is not uniform

Creates long floats

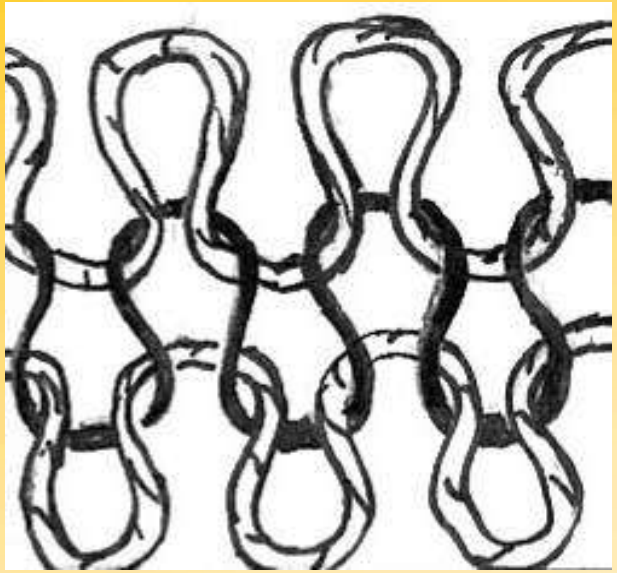
Interlacing weave passes over four or more yarns

Satin is the most obvious example



Knitted Fabric

Knitted fabrics are made by interlocking loops into a specific arrangement. It may be one continuous thread or a combination. Either way, the yarn is formed into successive rows of loops and then drawn through another series of loops to make the fabric.



Polymers

Synthetic fibers are made of polymers, which are long chains of repeating chemical units.

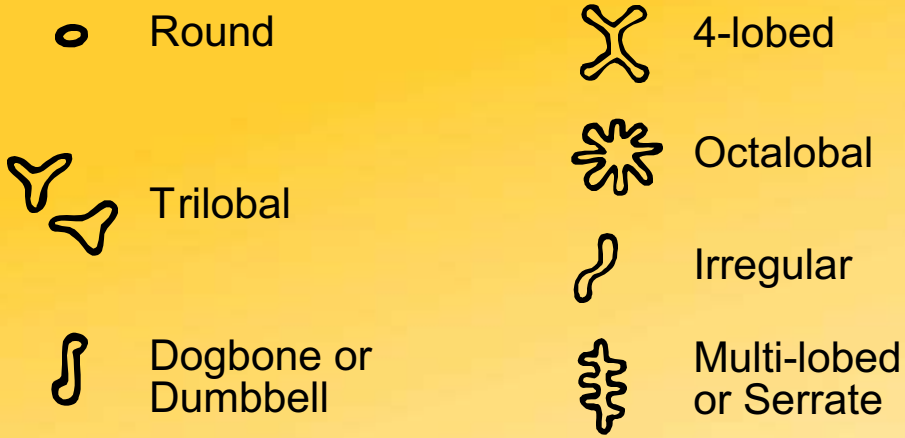
The word *polymer* means many (*poly*) units (*mer*).

The repeating units of a polymer are called monomers.

By varying the chemical structure of the monomers or by varying the way they are joined together, polymers are created that have different properties.

As a result of these differences, they can be distinguished from one another forensically.

Filament Cross Sections



Synthetic fibers are forced out of a nozzle when they are hot, and then they are woven. The holes of the nozzle are not necessarily round; therefore, the fiber filament may have a unique shape in cross section.

Testing for Identification

Microscopic observation

Burning—observation of how a fiber burns, the odor, color of flame, color of smoke, and the appearance of the residue

Thermal decomposition—gently heating to break down the fiber to the basic monomers

Chemical tests—solubility and decomposition

Testing for Identification

Density—the mass of an object divided by the volume of the object

Refractive index—measurement of the bending of light as it passes from air into a solid or liquid

Fluorescence—absorption and reemission of light; used for comparing fibers as well as spotting fibers for collection

Dyes

Components that make up dyes can be separated and matched to an unknown.

There are more than 7,000 different dye formulations.

Chromatography is used to separate dyes for comparative analysis.

The way a fabric accepts a particular dye may also be used to identify and compare samples.

Collection of Fiber Evidence

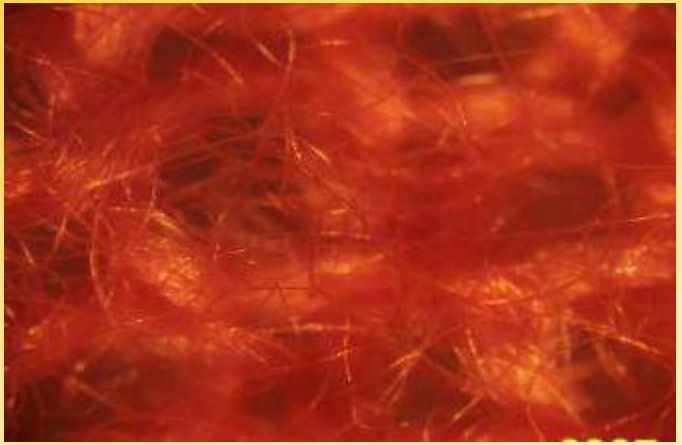
Bag clothing items individually in paper bags. Make sure that different items are not placed on the same surface before being bagged.

Make tape lifts of exposed skin areas and any inanimate objects.

Removed fibers should be folded into a small sheet of paper and stored in a paper bag.

Fiber Evidence

Fiber evidence in court cases can be used to connect the suspect to the victim or to the crime scene. In the case of Wayne Williams, fibers weighed heavily on the outcome of the case. Williams was convicted in 1982 based on carpet fibers that were found in his home, in his car, and on several murder victims.



More about Fibers

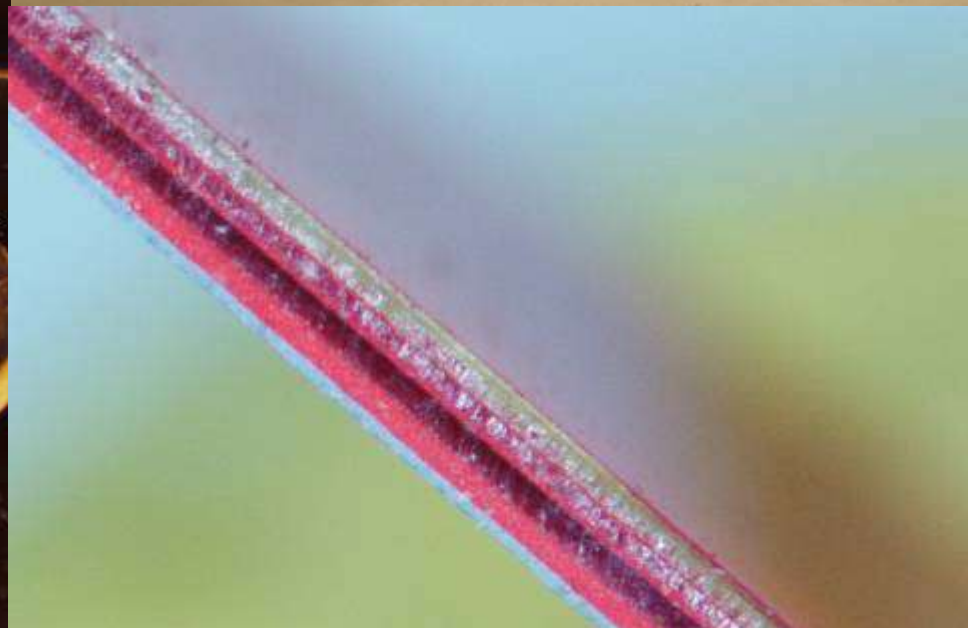
For additional information about fibers and other trace evidence, check out truTV's Crime Library at:

www.crimelibrary.com/criminal_mind/forensics/trace/1.html

Chapter 9 Trace Evidence

"Breadth of view is one of the essentials of our profession. The interplay of ideas and the oblique use of knowledge are often of extraordinary interest."

—*Arthur Conan Doyle's Sherlock Holmes, in* The Valley of Fear



Trace Evidence

Trace evidence is physical evidence found in small amounts at a crime scene. Common examples would be hair, fiber, paint chips, body fluids, stains, powders, explosive residue, glass particles, vegetative matter, metal particles, and soil. It may also include more unusual types of evidence.

Physical and Chemical Properties

Physical property: A characteristic that does not involve a change in the identity of a substance, such as odor, color, boiling point, density, refractive index

Chemical property: A characteristic that determines how a substance will change into another substance with different physical properties

Metal Analysis

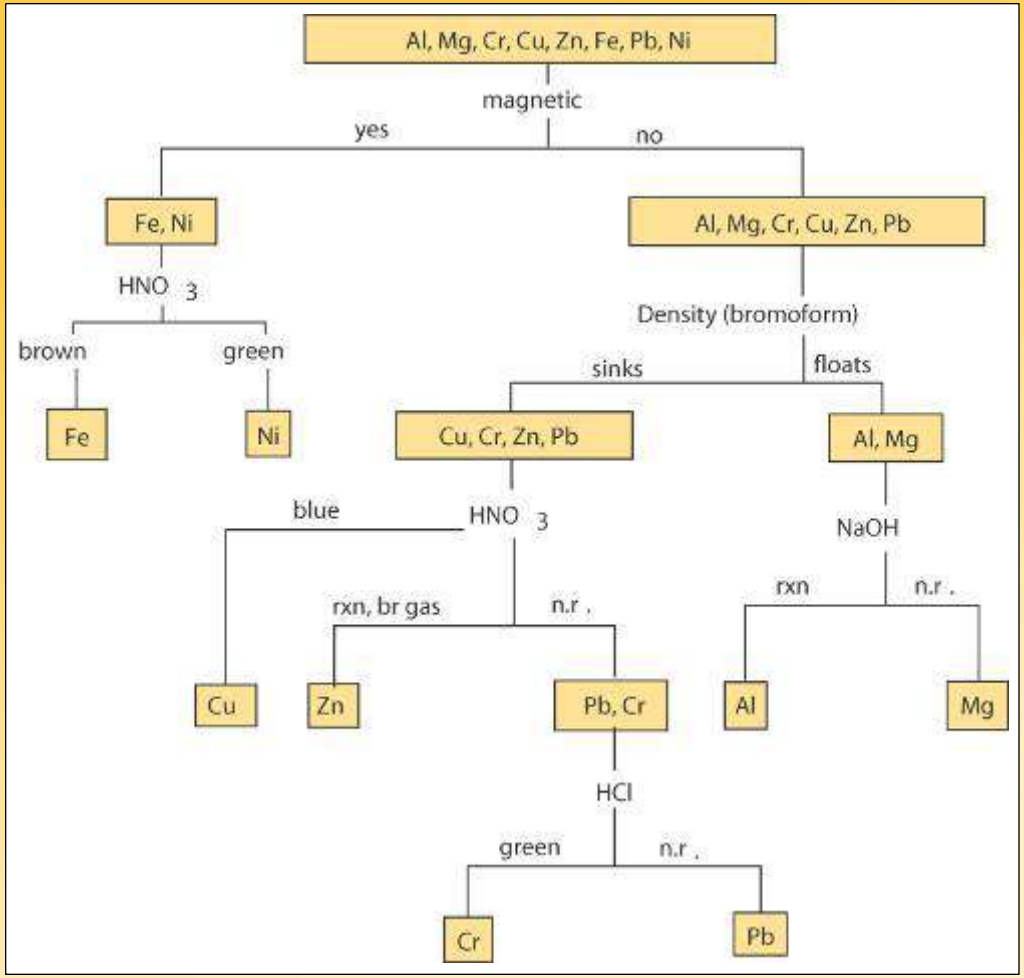
Bits of metal can be identified from their physical and chemical properties.

Solid particles—microscopic examination, magnetism, malleability, density, color, solubility, reactivity

Dissolved metals—separation by chromatography with comparison of R_f values to known metals, specific reactions, and color tests

Analysis of Metal Particles

A Qualitative Analysis Approach



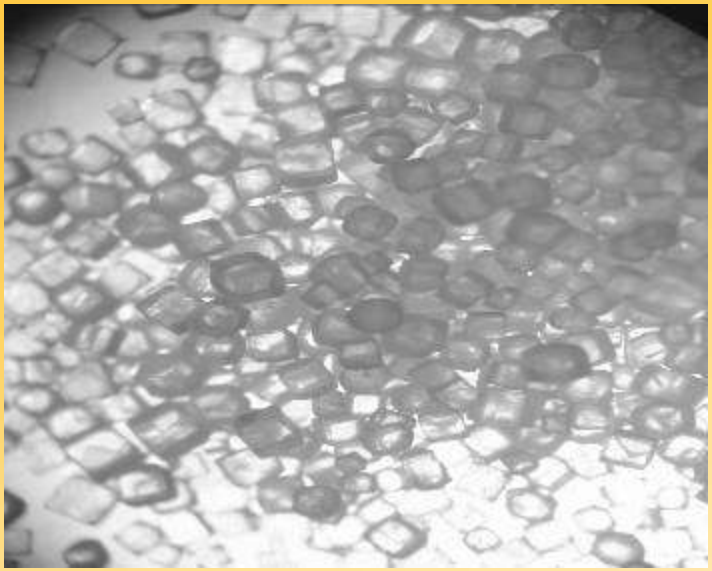
Trace Evidence: Qualitative Analysis

When investigators find substances at the scene of a crime and send them to the laboratory for identification, the forensic chemist uses several techniques or lab tests to identify them. One of these techniques is qualitative analysis. For example:

A number of white powders that appear the same can be identified by their physical and chemical properties.

Qualitative Analysis

Microscopic Examination



Qualitative Analysis, *continued*

Check for:

Solubility

pH

Chemical reactions

- Color
- Precipitate formation
- Evolution of gas

Flame Colors

Many metal salts show a distinct color when heated.

Sometimes this property can be used in an analysis.

A Historical Crime

In 1912, Emile Gourbin was a bank clerk in Lyons, France. He came under suspicion of strangling his girlfriend, Marie Latelle. Gourbin was arrested but had what appeared to be an airtight alibi. Edmond Locard went to Gourbin's cell and removed scrapings from under his fingernails. The scrapings contained tissue that possibly came from Marie's neck, but this was not provable. Locard noticed that the tissue was coated with a pink dust, which he identified as rice starch. On the particles he found bismuth, magnesium stearate, zinc oxide, and a reddish iron oxide pigment called Venetian red. Examination of the face powder used by Marie revealed that a powder prepared for her by a Lyons druggist was similar in composition. In these days of mass-produced face powder, this evidence would have far less significance. However, in 1912, because of the special preparation, it led to the confession of Gourbin.

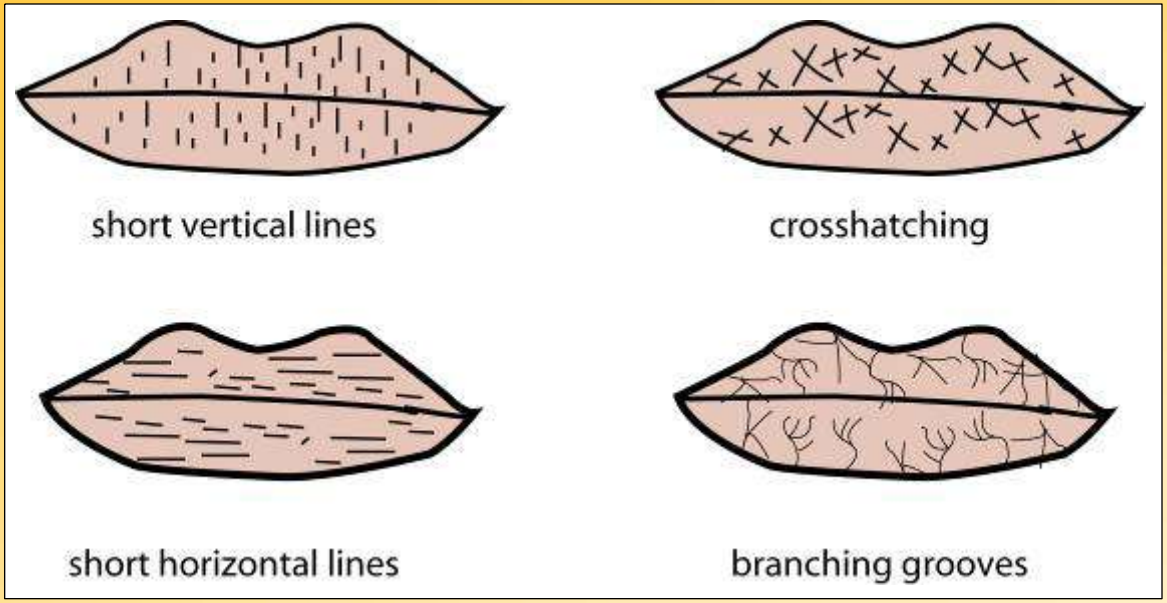
A More Recent Crime

A bank robber was startled by an alarm just as the teller handed her the money. She grabbed it and, in her haste to get away, ran smack-dab into a glass door. Nevertheless, she recovered and got away. Subsequent examination of the door revealed a red lipstick imprint of the perpetrator's mouth. Police later picked up a suspect, but needed evidence to link her to the robbery. Are lip prints unique enough to tie the suspect to the crime?

http://www.hbo.com/autopsy/episode/episode_6_the_telltale_imprint.html

Lip Prints

Lip prints are different and can be used to identify suspects. There are several general patterns:



Chromatography of Lipsticks

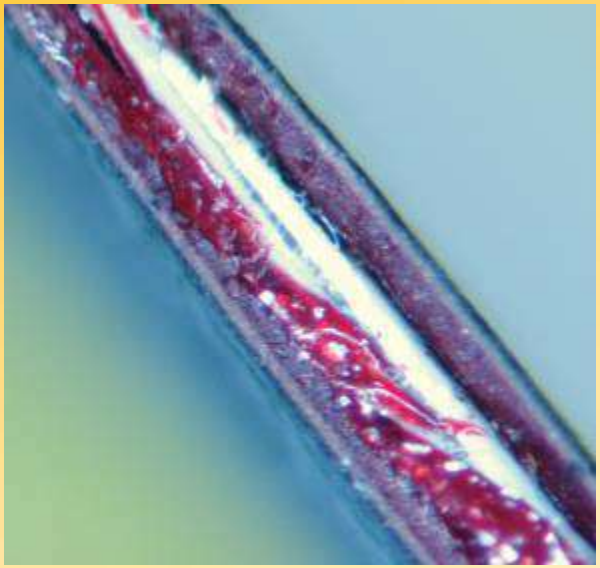
The lipstick used by the suspect could also have been compared to the residue on the door.

Thin-layer chromatography (TLC) can be used to separate the components of a lipstick. The chromatograms can then be compared for a possible match.

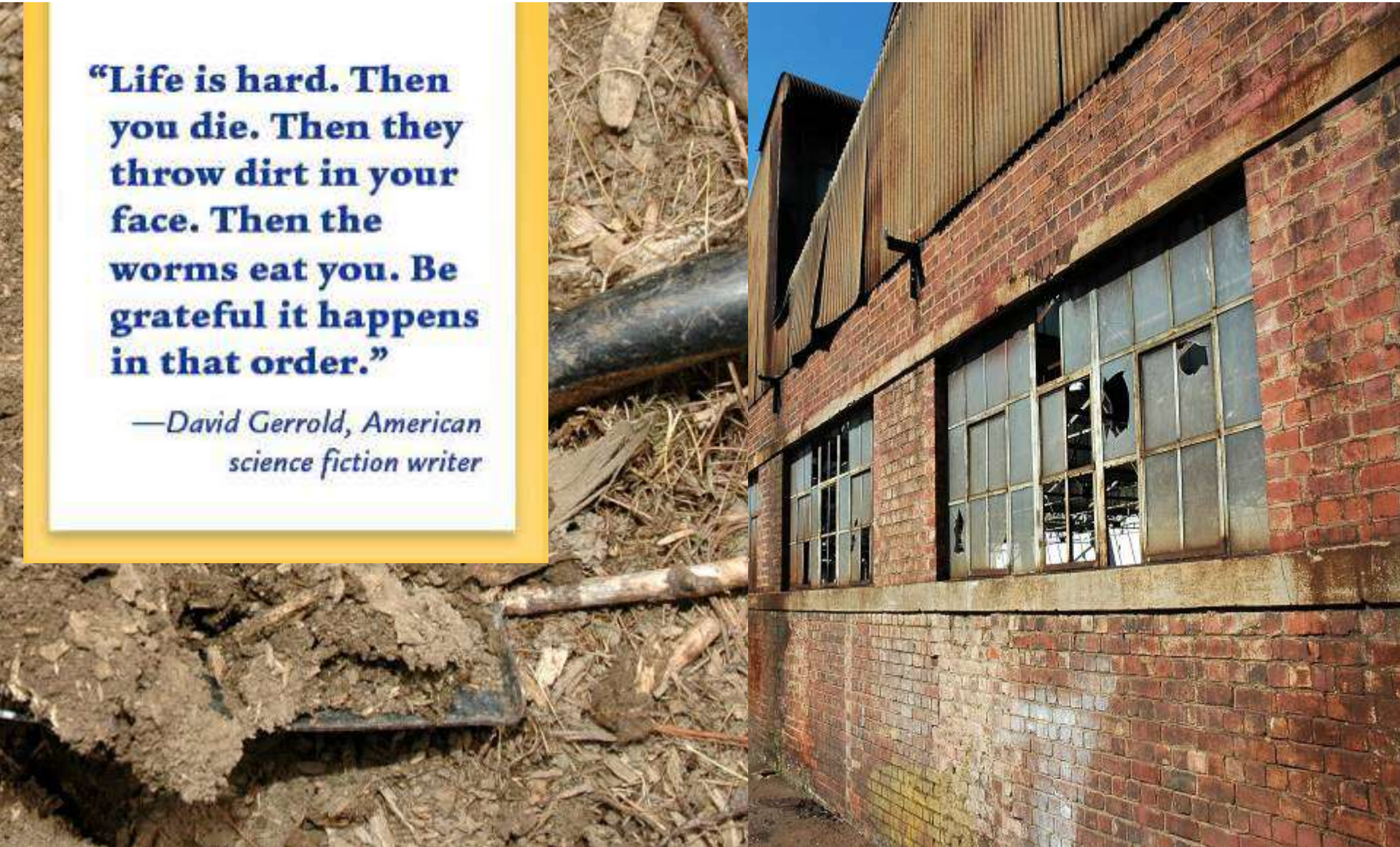
Paint

Paint can be used as evidence in hit-and-run cases.

The layers of different paints in a cross section may be unique.



Soil and Glass Analysis



Objectives, *continued*

You will be able to:

- Make density measurements on very small particles.
- Use logic to reconstruct events.
- Use technology and mathematics to improve investigations and communications.
- Identify questions and concepts that guide scientific investigations.

Forensic Geology

The legal application of earth and soil science

Characterization of earthen materials that have been transferred between objects or locations and the analysis of possible origin or sources

Forensic Geologist Tools

Binocular microscopes

Petrographic microscopes

X-ray diffraction

Scanning electron microscopes

Microchemical analysis

Forensic Geology History

1887–1893—Sir Arthur Conan Doyle wrote about scientific ideas and techniques for solving crimes in his writings of Sherlock Holmes. This included information about soil and its composition which had never actually been used.

1893—An Austrian criminal investigator, Hans Gross, wrote that there should be a study of "dust, dirt on shoes and spots on cloth." He observed, "Dirt on shoes can often tell us more about where the wearer of those shoes had last been than toilsome inquiries."

Forensic Geology History, *continued*

1904—Georg Popp, a German forensic scientist, presented the first example of earth materials used as evidence in a criminal case, the strangulation of Eva Disch.

1910—Edmond Locard, a forensic geologist, was most interested in the fact that dust was transferred from the crime scene to the criminal. This helped to establish his principle of transfer.

Soil

- **Definition—**naturally deposited materials that cover the earth's surface and are capable of supporting plant growth

- **The Earth**
  - **75 percent—**oceans, seas, and lakes
  - **15 percent—**deserts, polar ice caps, and mountains
  - **10 percent—**suitable for agriculture

Soil, *continued*

- **Formation**
  - **Living matter**—plants, animals, microorganisms
  - **Inorganic materials**
  - **Climate**
  - **Parent materials**
  - **Relief**—slope and land form
  - **Time**

Soil, *continued*

- **Profile**
  - **Topsoil**
  - **Subsoil**
  - **Parent material**
- **Composition**
  - **Sand**
  - **Silt**
  - **Clay**
  - **Organic matter**

Soil, *continued*

- Nutrients—macro
  - Nitrogen
  - Phosphorus
  - Potassium
  - Calcium
  - Magnesium
  - Sulfur
- Nutrients—micro
  - Manganese
  - Iron
  - Boron
  - Copper
  - Zinc
  - Molybdenum
  - Chlorine

Soil Comparisons

May establish a relationship or link to the crime, the victim, or the suspect(s)

Physical properties—density, magnetism, particle size, mineralogy

Chemical properties—pH, trace elements

Probative Value of Soil

Types of earth material are virtually unlimited. They have a wide distribution and change over short distances.

As a result, the statistical probability of a given sample having properties the same as another is very small.

Evidential value of soil can be excellent.

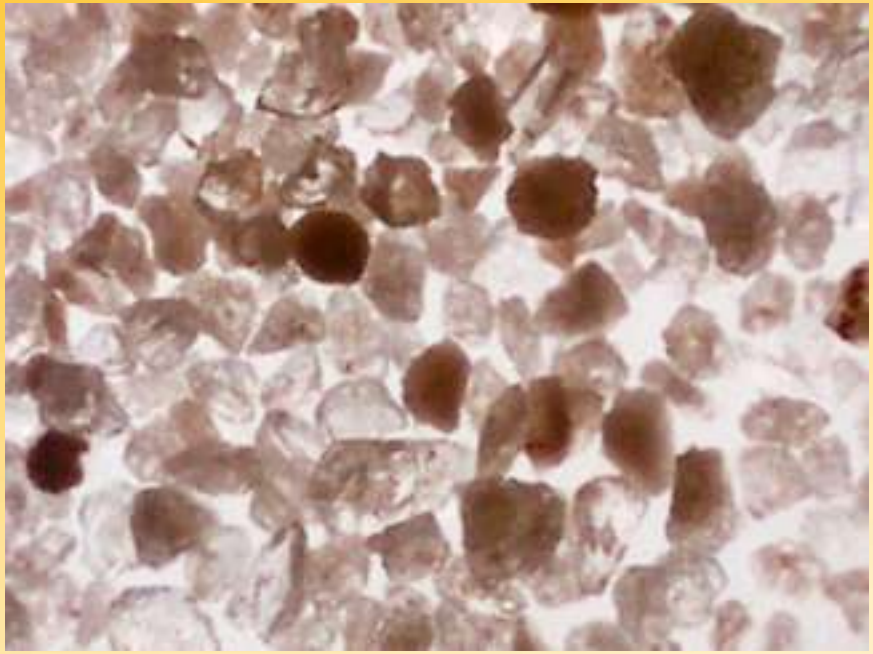
Increasing Probative Value

Rare or unusual minerals

Rocks

Fossils

Manufactured particles



Minerals

More than 2,000 have been identified.

Twenty or so are commonly found in soils; most soil samples contain only three to five.

Characteristics for identification —size, density, color, luster, fracture, streak, magnetism

Rocks

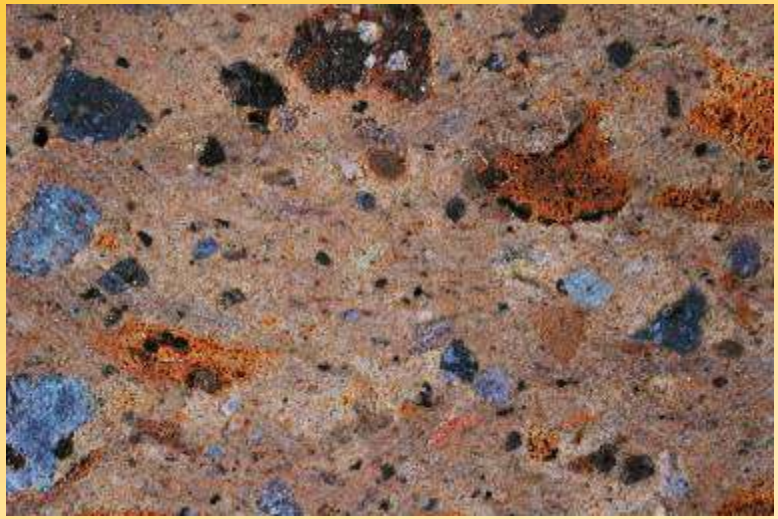
Aggregates of minerals

Types

- **Natural**—like granite
- **Man-made**—like concrete

Formation

- **Igneous**
- **Sedimentary**
- **Metamorphic**



Palynology

The study of pollen and spores

Important to know:

- What is produced in a given area
- The dispersal pattern

Variation in size and weight

For additional information about palynology, visit:

http://science.uniserve.edu.au/faces/milne/milne.html

Soil Evidence

Class characteristics—the type of soil may have similar characteristics at the primary and/or secondary crime scene, on the suspect or on the victim

Individual characteristics—only if the soil has an unusual or specialized ingredient such as pollen, seeds, vegetation, or fragments

Sand

Sand is the term applied to natural particles with a grain diameter between 1/16 mm and 2 mm.

Its color and contents are dependent upon the parent rock and surrounding plant and animal life.

(The photo on the right shows color differences in sand from six locations around the world.)

Sand Characteristics

Composition is based on the material of the source; also gives the sand its color

Texture is determined by the way the source was transported

- Shape
- Grain size
- Sorting

Forensic Geology in the News

A nine-year-old's body was found in a wooded area along a river in Lincoln County, South Dakota. A forensic geologist collected soil samples from the fenders of a suspect's truck and from the area where the body was found. Both soils contained grains of a blue mineral that turned out to be gahnite, a rare mineral that had never been reported in South Dakota. As a result, the soil tied the suspect to the crime.

Check out other cases at:

www.forensicgeology/science.htm

Characteristics of Glass

- Hard, amorphous solid
- Usually transparent
- Primarily composed of silica, with various amounts of elemental oxides
- Brittle
- Exhibits conchoidal fracture

Common Types

Soda-lime—used in plate and window glass, glass containers, and electric lightbulbs

Soda-lead—fine tableware and art objects

Borosilicate—heat-resistant, like Pyrex

Silica—used in chemical ware

Tempered—used in side windows of cars

Laminated—used in the windshield of most cars

Physical Characteristics

Density—mass divided by volume

Refractive index (RI)—the measure of light bending due to a change in velocity when traveling from one medium to another

Fractures

Color

Thickness

Fluorescence

Markings—striations, dimples, etc.

Density

Type of Glass	Density
window	2.46–2.49
headlight	2.47–2.63
Pyrex	2.23–2.36
lead glass	2.9–5.9
porcelain	2.3–2.5

Determination of Refractive Index

Immersion method—lower fragments into liquids whose refractive index is different

Match point—when the refractive index of the glass is equal to that of the liquid

Becke line—a halo-like glow that appears around an object immersed in a liquid. It disappears when the refractive index of the liquid matches the refractive index of the object (the match point).

Determination of Refractive Index, *continued*

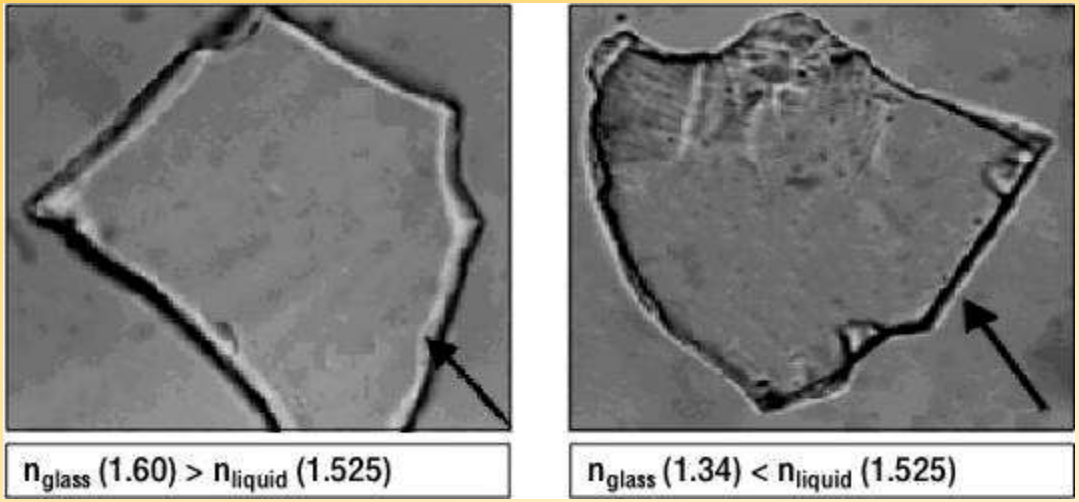
The refractive index of a high-boiling liquid, usually a silicone oil, changes with temperature.

This occurs in an apparatus called a hot stage which is attached to a microscope. Increasing the temperature allows the disappearance of the Becke line to be observed.

At match point, temperature is noted and refractive index of the liquid is read from a calibration chart.

The Becke Line

The Becke line is a "halo" that can be seen on the inside of the glass on the left, indicating that the glass has a higher refractive index than the liquid medium. The Becke line as seen on the right is on the outside of the glass, indicating just the opposite.



Refractive Index

Liquid	RI	Glass	RI
Water	1.333	Vitreous silica	1.458
Olive oil	1.467	Headlight	1.47–1.49
Glycerin	1.473	Window	1.51–1.52
Castor oil	1.482	Bottle	1.51–1.52
Clove oil	1.543	Optical	1.52–1.53
Bromobenzene	1.560	Quartz	1.544–1.553
Bromoform	1.597	Lead	1.56–1.61
Cinnamon oil	1.619	Diamond	2.419

Fracture Patterns

Radial fracture lines radiate out from the origin of the impact; they begin on the opposite side of the force.

Concentric fracture lines are circular lines around the point of impact; they begin on the same side as the force.

3R rule—*Radial* cracks form a *right* angle on the *reverse* side of the force.

Sequencing

A high-velocity projectile always leaves a wider hole at the exit side of the glass.

Cracks terminate at intersections with others. This can be used to determine the order in which the fractures occurred.

Glass as Evidence

Class characteristics: physical and chemical properties such as refractive index, density, color, chemical composition

Individual characteristics: if the fragments can fit together like pieces of a puzzle, the source can be considered unique

Considerations for Collection

The collector must consider that fragments within a questioned sample may have multiple origins. If possible, the collector should attempt an initial separation based on physical properties.

The collector must consider the possibility that there may be a physical match to a known sample (e.g., a piece of glass to a fractured vehicle headlamp). When an attempt to make a physical match is made at the site of collection, the collector should take precautions to avoid mixing of the known and questioned samples.

Any glass samples collected should be documented, marked (if necessary), packaged, and labeled.

—Forensic Science Communications

Collecting the Sample

The glass sample should consist of the largest amount that can be practically collected from each broken object and packaged separately. The sample should be removed from the structure (e.g., window frame, light assembly). The inside and outside surfaces of the known sample should be labeled if a determination of direction of breakage or reconstruction of the pane is desired.

When multiple broken glass sources are identified, it is necessary to sample all sources.

A sample should be collected from various locations throughout the broken portion of the object in order to be as representative as possible.

The sample should be collected with consideration being given to the presence of other types of evidence on that sample (e.g., fibers, blood).

—Forensic Science Communications