Forensic Science

MIKE SZYDLOWSKI

CRIME SCENES THEFT DETECTION PHYSICAL EVIDENCE
BLOOD TYPING BLOOD SPLATTER FORENSIC GENETICS
ELECTROPHORESIS FINGERPRINTING FORENSIC PATHOLOGY
ENTOMOLOGY TOXICOLOGY HAIR & FIBER TOOL MARKS
FOOT PRINTS TIRE TREADS PATERNITY CASES
CASE STUDIES CRIME SIMULATIONS FORENSIC REPORTING

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Crime Scene

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Blood Typing

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Hair & Fiber Analysis

Toxicology

Death Investigations

An Introduction To Forensic Science

Contents

Caution!!!

- Always use gloves when inspecting a crime scene. You do not want to contaminate the evidence.
- Always use caution not to trample over tiny evidence at a crime scene. Once trampled, obtaining the evidence would be very difficult.

Did You Know?

Examples of Forensic Evidence

fresh blood	dry blood	blood splatter
soda straws	facial tissue	soda can
eye glasses	hair	comb
lipstick	footprint	ear print
tire tracks	paint chips	headlight glass
fingerprints	finger nails	clothing
fibers	urine	shoe lace
writing	paper	ink pens
printers	money	weapons
plastic bags	tape	saliva
e-mail	pillow	vegetation
drugs	alcohol	moved furniture
carpet fiber	powders	gun residue
blanket	car fibers	computers
diatoms	victim	beetles
maggots	flies	dirt
dust	lightbulbs	light switch
door handle	trash cans	stomach contents
voice print	video	telephone records
cigarettes	cigars	chewed gum
newspaper	mail	candy wrapper

All of these types of evidence have been used to help solve a crime in addition to many more obscure pieces of evidence. Everything left at a crime scene, no matter how small, should be considered evidence.

Introduction to Forensic Science

What is Forensic Science?

Forensic science, or criminalistics, is the application of scientific principles to crime solving. Many in the media use the terms forensics and criminology interchangeably. This is a mistake - they have two very different meanings. Remember, forensics is the application of science to law. **Criminology** is the study of crime in the social setting. Criminology would study why criminals commit such crimes, the effect on society and crime trends. Today, forensics is used in many different ways to solve many different types of cases. Here are several examples:

- Forensics can be used to solve a murder case by examining evidence left at a crime scene.
- Forensics can be used to determine the cause of death in a accidental poisoning case.
- Forensics can be used to detect money or art forgeries.
- Forensics can be used to make sure food and drug labels are accurate and in accordance to regulations.

This is just a sample of many of the tasks that can be performed by forensic scientists. If there is any case or investigation that can be solved using science then it is considered forensic science.

Locard's Exchange Principle

One of the most interesting aspects of forensic science is being able to solve a crime by connecting a piece of fiber found at a crime scene to a coat containing that fiber in a suspects closet. This discovery was first made by Edmond Locard (1877-1966). Locard stated that whenever two objects come in contact, there will be an exchange of materials between them. For example, every time you walk into your classroom you are leaving traces of your existence. Some examples of this would include: flakes of skin, strands of hair, fibers from your clothing, fingerprints, and foot prints. In addition to you leaving behind traces of your existence, the classroom is also leaving traces of its existence on you. If we examined your clothes we might find traces of chalk, fibers from a carpet, or oil from your lab stools. In this case you would be considered the **primary transfer location**. If you were to give a friend a hug and chalk dust transferred from your jacket to their jacket, then they would be considered the **secondary transfer location.**

Because of the understanding of **Locard's Principle**, forensic scientists are now able to solve a crime by looking at very small pieces of evidence, called **trace evidence**. Trace evidence can be items as small as a strand of hair or a single strand of carpet fiber. To this date, many suspects have been sent to jail using nothing more than trace evidence.

Forensics in the News and Television:

During the last decade, and even more so recently, forensic science has gained a great deal of popularity on television and in the news media. This is probably in response to the public demanding more real life drama shows. Below is just a sampling of the more recent shows depicting crime drama situations.

Fox: Cops, America's Most Wanted, Highway Patrol, Bones

CBS: CSI, CSI Miami, CSI New York, Criminal Minds, Cold Case, Without a Trace

NBC: Dateline Interactive Mysteries, Criminal Intent, Law & Order

CABLE: The New Detectives, Forensic Science, Medical Examiner

While some of these shows are more dramatic than educational, some can teach the viewer a great deal of forensics while still entertaining large audiences. For example, *Medical Examiner* gives the viewer an insight to how suspects are brought to justice using the victims bodies. We will go more into that aspect later in the course.

O.J. Simpson Case:

No time in history has the public been entrenched with as much forensic science as was the case with the O.J. Simpson Murder Trial. Whether you agree or disagree with the outcome of the trial, this murder trial needs to be studied by all potential forensic scientists. It gives an insight into what really goes on in a murder investigation as well as how costly forensic lab mistakes can be to the prosecution.

On June 12, 1994 Nicole Brown Simpson and nine other friends went to eat dinner at Mezzaluna Restaurant, about a half a mile away from Nicole's condominium. Nicole's friend, Ron Goldman is a waiter at the restaurant. After dinner, Nicole called the restaurant because she forgot her prescription sunglasses at the table. The sunglasses were already found and placed in an envelope. On his way home, Ron Goldman agreed to drop the envelope with her glasses at Nicole's home.

A neighbor of Nicole found Nicole's dog out wandering the street unattended. The neighbor no-

tices that the dogs paws are covered with blood. The neighbor takes the dog to her own house and cleans the paws. The neighbor then took the dog back to Nicole's house where she found the bodies.

From almost the beginning, O.J. Simpson was a suspect. O.J. and Nicole Brown Simpson had a very rocky marriage together. It was reported that O.J. frequently lost his temper and lashed out at Nicole. After one such incident, Nicole had a friend take a picture of her bruised face and paper clipped it to an apology note O.J. had written her. Among other things, the note apologized for hitting her. Nicole placed the pictures and the note in a safe deposit box. She allegedly did this in case she ever needed proof of his abuse.

The most striking evidence from the case was the blood. Pools of blood at the crime scene consisted of a mixture of blood from Nicole, Ron, and another type consistent with O.J. Police also found blood dripped inside O.J.'s car. The blood was consistent with Nicole and Ron. Additional blood was found along a walk and inside O.J.'s house. The blood was also a combination of all three. Further DNA analysis also revealed that the blood at the crime scene belonged to O.J. Simpson. It has been scientifically proven that all individuals have a unique DNA sequence. The more DNA that scientists are able to isolate, the more positive they can be about the identity of a person. Some scientists have stated that one would have to have the population of ten earth's before finding another person with similar DNA. The prosecution used this knowledge to claim that O.J. had to be the killer. The defense team argued that the blood evidence was planted as part of a conspiracy against O.J. Simpson. Another piece of evidence the prosecutors tried to use to pin O.J. was a pair of black leather gloves found at the estate of O.J. Simpson. The prosecution boldly asked O.J. Simpson to put on the glove. In front of the jury the defendant tried to put on the glove and explained that he could not because it was too small.

What are some of the problems with this court case? First of all, the trial was more like a circus than anything else. The media was allowed in for national television viewers to follow almost every step of the trial. Some say that this caused both sides to lose their focus and pay more attention to grandstanding than conducting a fair hearing. Another problem was that potential jurors were asked hundreds of pre trial qualification questions. The defense team attempted to dismiss any potential juror that had a background in the sciences. This selection tactic allowed more latitude for the defensive attorneys in throwing out the DNA evidence. Another problem was the glove. Have you ever tried to put on a shoe after you left it in the rain and it had already sun dried? The wetting and drying process tends to shrink items. While this may or may not have been the case, trying on the glove was a poor tactic for the prosecution. Another problem for the prosecution was that several vials of O.J.'s blood were indeed missing from the lab. The fact that these vials are missing could give credibility to the defense claim that O.J.'s blood at the crime scene had been planted.

The O.J. Simpson case alone shows how important it is for forensic scientists to be very precise and accurate with their work. A simple mistake in their evidence analysis can lead to sending an innocent man to jail or setting a guilty man free. It also shows how important it is to be able to convey your findings to a jury. You could turn out to be one of the best forensic scientists of our time, but if you fail to convince juries of your findings you will be useless.

Terminology for Crimes and Criminals

Turn on any local or national news show and the most common news item will be crime that has taken place in the community. It is important that you become aware of the different types of crime and criminals. A thorough understanding of these terms will aid in your examination of their causes.

Burglary: A crime in which a persons home or business has been broken into and items were taken from that structure.

Date Rape: A crime in which the victim is forced into sex by a person he/she is familiar with or has been with the person willfully earlier in the day.

Extortion: A crime in which money or other belongings is taken through force, threat, or deception. This type of crime is most common in the business community.

Larceny: A crime in which a person's personal property is taken.

Mass Murderer: A person who kills at least four people at the same time. This crime is usually committed for revenge against people that the suspect knows. An example of this type of crime would be the Columbine School Shootings. The guilty suspects knew their students and were acting in revenge to being bullied in school.

Modus Operandi: The manner in which a person commits a crime. The type of victim, type of weapon, type of entry, and type of exit are all aspects of that criminals Modus Operandi.

Mugging: A crime in which the victim is assaulted for the act of taking the victim's belongings.

Rape: A crime in which the criminal has sexual intercourse with the victim without their consent.

Serial Killer: A person who kills more than four people over an extended period of time. Serial killers rarely know their victims. They are acting out of a need to enact power over someone or something.

Sociopath: A person that has no remorse for what they have done or are about to do. This person will often manipulate others before killing them.

Sodomy: A crime in which sexual intercourse between males has taken place or unusual sexual intercourse between a male and a female has taken place. Many times this crime will happen between a man and a young boy.

Spree Killer: A person who kills several people in different locations but in very short period of time. This person might be mad about a traffic ticket and may kill the officer and then go around killing other law enforcement personnel before being caught.

The History of Forensic Science

While great strides have been made in recent years, solving crime by using investigative scientific principles is not new. The first recorded use of what is now known as forensics was back in the 12th century when King Richard assigned a coroner to investigate the cause of death is suspicious cases. Forensics as we now know it began to truly develop in the last several hundred years. Since that time forensics has relied more and more on technology.

A Forensic Timeline

7th Century	Chinese used fingerprints to sign legal documents.
1810	First detective agency opens in France.
1836	James Marsh of England developed a method of detecting very small amounts of arsenic, As_2O_3, a highly toxic poison. Marsh Test was used in the 1840 conviction of Marie LaFarge, the first women to be convicted using forensic toxicology.
1838	First police force in the United States was set up in Boston.
1882	Alphonse Bertillon set up the first scientific measurement system to identify humans. He used a series of precise body measurements to set each person apart. This practice was called Anthropometry.
1891	Argentine Police Official, Juan Vucetich, was the first to classify finger prints for filing systems. In 1892 Juan made his first fingerprint identification.
1901	Karl Landsteiner of Austria discovered blood types in humans. He won the Nobel in 1930 for his work.
1910	Edmond Locard set up the first forensics science laboratory in Lyons France.
1911	Fingerprints were accepted for the first time in the United States (Chicago) courtroom.
1924	J. Edgar Hoover appointed head of F.B.I.
1987	DNA analysis first used in U.S. courts.

Divisions of Forensic Science

Despite what you might see on a dramatic forensic television show, a forensic scientist will have a specific function in their department. It is no longer true that one forensic scientist can analyze all the types of evidence found at the crime scene. This is because technology has advanced so quickly that it is necessary to have experts in the different forensic departments. Listed below is a summary of each type of forensic department.

Crime Scene Technicians:	Processes the crime scene for evidence, victims, and witnesses. Will be responsible for drawing up the crime scene and making a 3-D model of the scene if necessary in court.
Biology Unit:	Analyzes evidence such as body fluids, tissues, hair, and any other body parts for blood and DNA typing.
Chemistry Unit:	Analyze trace evidence such as paint, glass, soil, and unknown substances for their identity and possible connection to a suspect.
Toxicology Unit:	Analyze bodily fluids for the presence of drugs and/or poisons that may have played a factor in a crime.
Document Examination:	Analyze documents, art, and money for signs of forgeries and tampering.
Toolmark Identification:	Analyze tool marks at a crime scene to connect them with known tools from a suspects home or possession.
Fingerprinting Unit	Dust, lift, and analyze fingerprints at a crime scene.
Criminal Profiling:	Will analyze the crime scene to get an idea as to what type of person could have committed such a crime.
Firearms Unit:	Analyze items such as shell casing, guns, and bullet holes to try to match the evidence at a crime scene with a known source.

Death Investigation:	Analyze human remains to try to identify the cause of death and search for clues that may have belonged to the suspect.
Entomology Unit:	May work alongside death investigators to determine how long a body has been dead by observing the types of bugs on the decaying body.
Odontology Unit:	May work alongside death investigators to find the identity of a victim by observing the victims teeth and comparing them to known X-rays of past dental patients.

As technology evolves, so does the role of the forensic scientist. Due to the escalating numbers of violent crimes in the United States, the need for forensic scientists is expected to rise considerably. Students interested in becoming a forensic scientist will need a minimum of a bachelor's degree in forensics. After the student has found a job, they will most likely go back and get a specialized masters degree. The average starting salary for a forensic scientist is about $30,000. The average salary for specialized forensic scientists is $65,000, with some making over $100,000. Forensic scientists in the medical fields and highly technical fields will make over the average specialized salary.

Forensic Science Assessment

You have chosen to take a class in forensic science. While the class is filled with exciting examples of how science is used to solve crimes, you should also note that being a forensic scientist is a lot of work. Unlike what you see on television, crimes are not solved in one hour. It may take many weeks to years to solve one crime. This class is a great example of the level of effort needed to be a forensic scientist. There are too many details and topics in forensics to cover in a class. It is up to the student to investigate some topics on their own and practice their skills in the "Forensic Science Assessments". Only students who master the work in class and the work outside of class will get the most benefit and have the most success in this class.

1. Using the Internet, find three true crimes that were solved using forensic science. Briefly summarize each example in a typed paragraph. Be sure to include how forensic science solved the crime.

2. Type a paragraph showing your understanding of the Locard Principle. Explain the principle and give an example of how it is used. This paragraph should be in your own words.

3. Using the Internet, discover what is included in a typical crime laboratory. Type out your findings in a list format, rather than a paragraph. Be sure to include an explanation of what each division does and what equipment they may need.

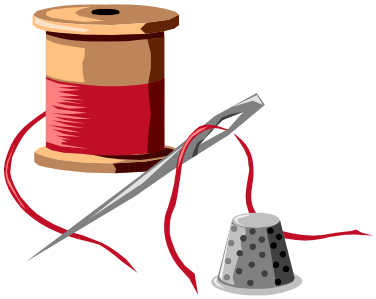
4. Using the Internet, create a list of ten forensic science websites that may be useful to someone wanting to learn about the subject. List the address and include a brief description of what can be found on that site. Give the site an overall rating.

This entire assignment should be typed in a professional format. Turn in the entire assignment at one time. Your final product should be about 4-5 pages. Your grade will be based on the quality of research and the quality of the report.

Introduction Assignment Rubric

Part 1: Forensic Crimes & How They Were Solved	Crime #1 5 points	Crime #2 5 points	Crime #3 5 points	Total Points Earned Part 1 15 possubke
Part 2: Locard's Principle & Example	Theory Explained 5 points	Example of Theory 5 points		Total Points Earned Part 2 10 possible
Part 3: Crime Labooratory	Materials in a Lab 5 points	Divisions of a lab 5 points	Job of Division 5 points	Total Points Earned Part 3 15 possible
Part 4: Website Critique	10 sites listed 5 points	10 sites evaluated 5 points		Total Points Earned Part 4 10 possible
Overall Quality 10 Points				Total Points Report Quality 10 possible
			FINAL GRADE 60 possible	

The Study of Hair and Fiber



Contents

Caution!!!

- Students should wear gloves and wash hands during and after all laboratory parts of this unit.
- Sharp objects are used in this lab. Great care should be taken in handling these objects.

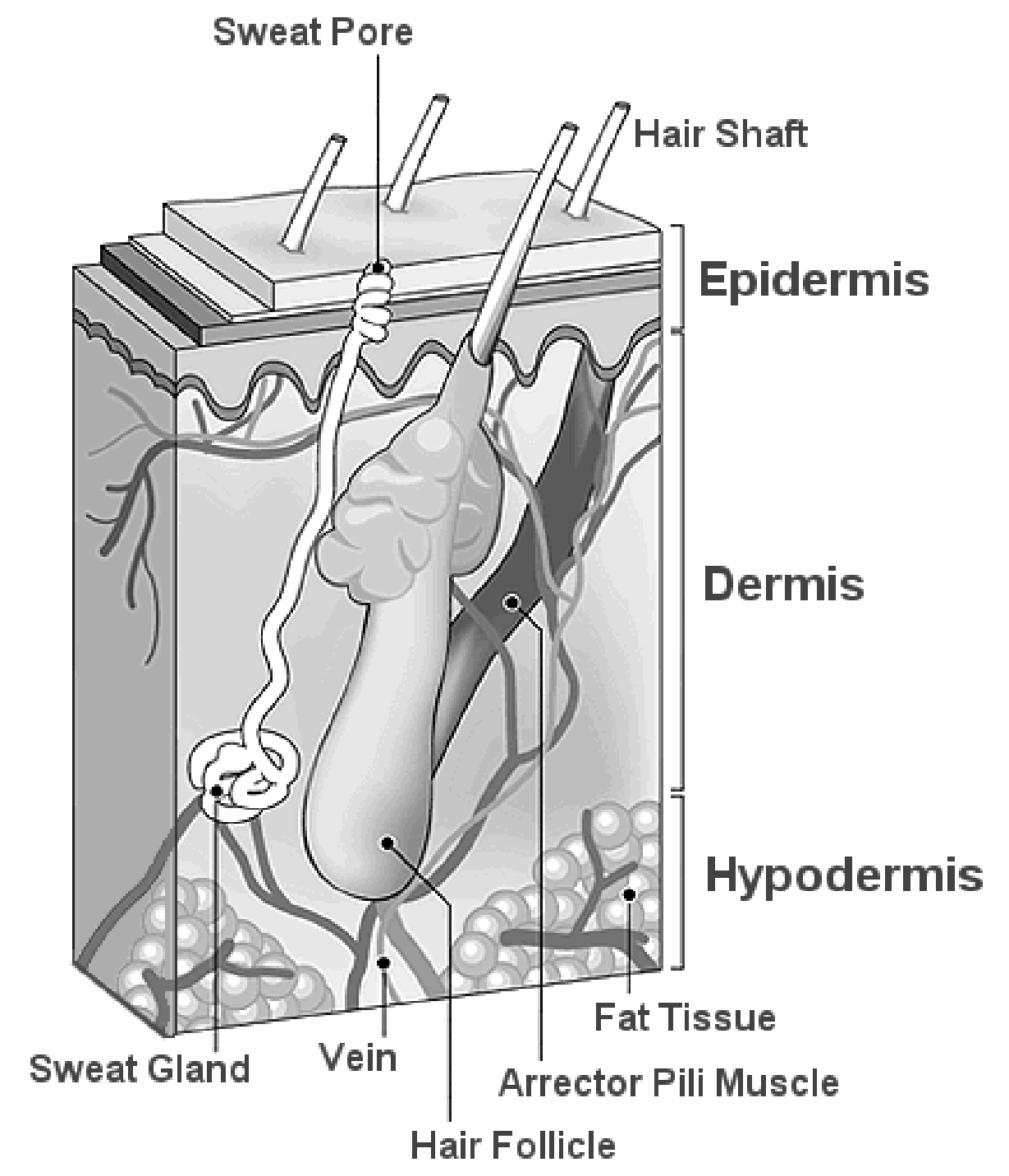
Did You Know?

Hair & Fiber Evidence Statistics

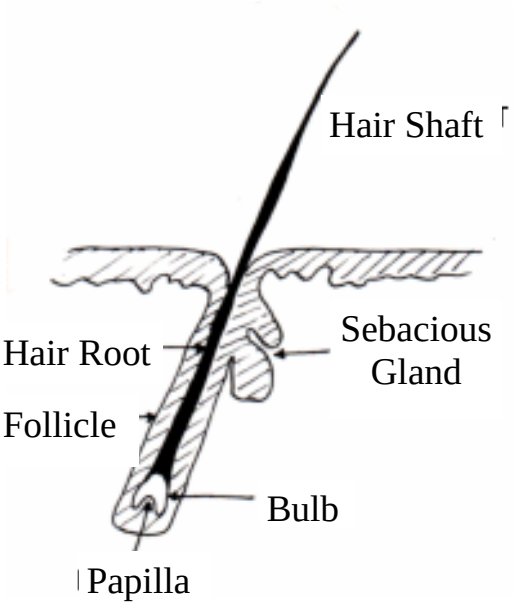
- Trace Evidence, including hair and fiber can never be used to positively match one individual to a crime. It can only be used as circumstantial evidence. This is because of the large numbers of people having the same or similar hairs and fibers. Evidence of the large amounts of trace evidence can be seen below.
- The average human head contains about 120,000 hairs growing at a rate of half an inch a month. An average hair will continue to grow for 2-3 years.
- 45 billion pounds of cotton fibers are produced each year.
- There are currently about 1,900 fiber manufactures throughout the world. Each manufacturer may use a slightly different technique, chemical, or dye that will give the fiber a unique composition.
- Over 8,000 different dye formulas are available for dying fabric.
- Over 120,000 manufacturers use a combination of fibers in making their products. This makes finding the exact developer of a particular fiber very difficult.
- However, carpet fibers in the Atlanta Child Murder case were traced back to their original manufacturer.

The Composition and Structure of Hair

Hair is composed of a protein called Keratin. Every species of animal, including humans, contains characteristic hair length, color, and structure. Using microscopic analysis of the hair, a forensic scientist can determine what type of species the hair came from. In humans, hair can sometimes be linked back to an individual suspect. The accuracy of matching one human hair to a single person is not nearly as accurate as fingerprinting or DNA analysis but it still can give clues to the guilty suspect.



The hair that you can see coming out of your skin is called the hair shaft. The hair that is just below sight is the start of the hair root, which forms into a club shape at the origin of the hair strand. The hair follicle is the structure in which the hair is being held. Hair grows from the papilla and pushes the current hair out by adding cells to the bulb area of the hair. Hair is naturally oily due to excretions from the sebacioius gland, however frequent shampooing will make the hair much less oily.



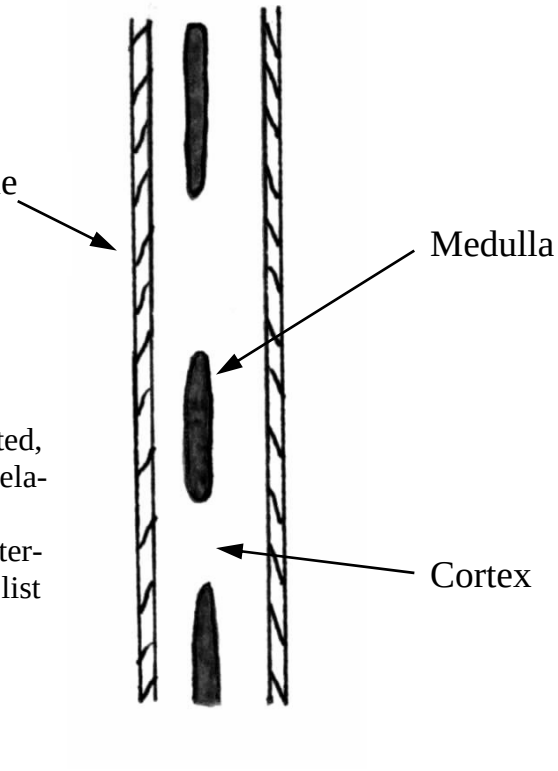
The hair shaft can be divided into three additional sections; the cuticle, cortex, and medulla. It is these three sections that are important to forensic scientists as they can give clues to the type of species and area on the body they came from.

Cuticle

This is the outside covering of the hair and is formed by overlapping scales. If left uncut, the tip of the cuticle will be pointed. The scale pattern is formed when in the hair follicle and can be used to determine the species the hair came from. The scales can only give class characteristics, not individual characteristics. For example, a strand of hair may have scales that are similar to a greyhound dog. While this is useful in narrowing down the type of dog, it can not be used to determine exactly which greyhound dog it came from.

Cortex

The cortex is located just under the cuticle. Hair pigmentation granules are located in this region. Hair is not uniformly colored. Hair pigmentation is rather blotchy as can be seen under a microscope.

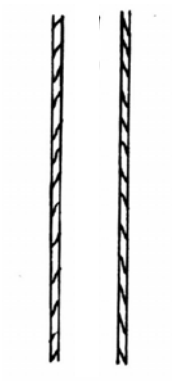


Medulla

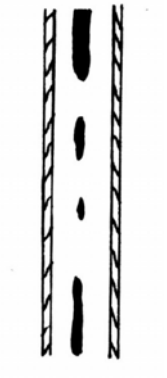
The very center part of the hair is called the medulla. Not all species or individuals have a medulla. The medulla can be classified as absent, fragmented, interrupted, or continuous. The medulla is measured in the relation to in relation to the width of the hair shaft to give a medullary index. This index. This index can be used to help determine the type of species and sometimes even narrow down a list of potential suspects.

$$\text{Medullary Index} = \frac{\text{Diameter of Medulla}}{\text{Diameter of Hair Shaft}}$$

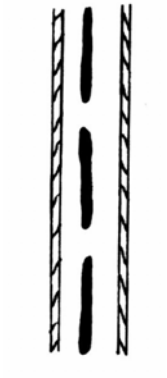
Medulla Patterns for Identification and Classification



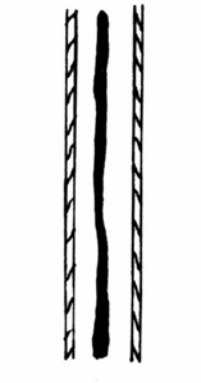
Absent



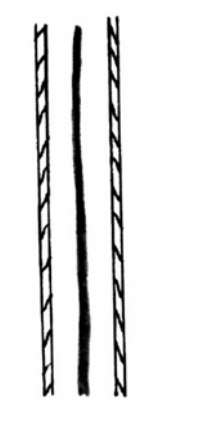
Fragmented



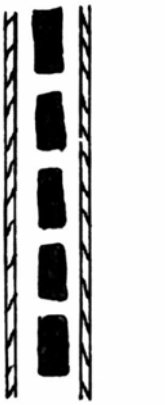
Interrupted



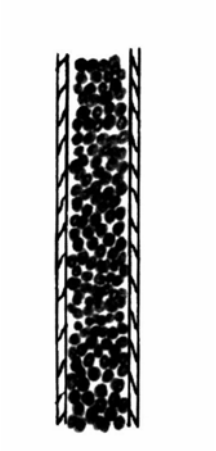
Continuous



Dog

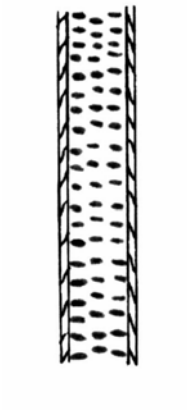


Cow

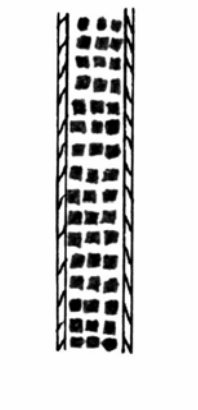


Deer

Fox



Mouse



Rabbit

Raccoon

Note: Human hair

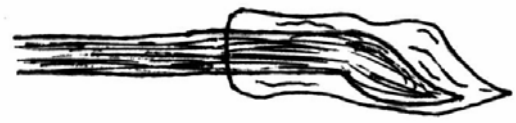
Note: Human hair usually has no medulla or a fragmented medulla.

The Biology of Hair Growth and Shedding

There are three stages of hair growth: the anagen, catagen, and telogen phases. The phase of hair growth may be determined by simple examinations with a light microscope. The details of each phase of hair development is outline below.

Anagen

During this phase the hair is actively growing. This occurs when the cells around the papilla are dividing and being deposited upward, creating additional hair shaft. In a healthy person, about 85% of the hair is in the anagen phase. During this stage, the hair is held together by the papilla, the follicle, and surrounding tissue. Any hair that is dislodged at this phase must be pulled out. Pulled hair will often kink the area just above the club shaped part of the root. In addition, hair follicle tissue will often be seen attached to the root of the hair. This tissue around the root is an excellent source of DNA. Notice how the club shape part of the root is bent.



Catagen

This phase is the transition phase between the active anagen phase and the dormant telogen phase. At times the hair in the telogen phase is simply pausing in the development of the hair. If this is the case, the phase could go back to anagen phase. About 3% of all hair is in the catagen phase.

Telogen

Approximately 12% of all hair is in this phase. At this point, the growth has stopped and the hair is only held in by the larger root. A simple pull or combing can easily dislodge this hair. In contrast to a hair pulled in the anagen stage, hair lost during the telogen stage will have no tissue or root damage. These hair samples are not suitable for DNA examinations. Through the normal course of a day, a healthy human loses about 100 strands of hair that were in the telogen phase.

Human Hair Types

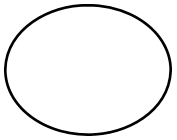
Head Hairs	-	Often the longest and the tip is often flat as a result of scissor cutting. Environmental or manmade alterations may be visible on the hair. Head hair is suitable for forensic analysis.
Pubic Hairs	-	Have a flattened cross section, making the hair shaft kink or curl. These hairs are not subject to environmental or manmade alterations so samples will remain similar for years. Public hair is suitable for forensic analysis
Facial Hairs	-	Have angled tips from razor cutting. Not suitable for forensic analysis.
Limb Hairs	-	Are short in length with an arcing shape. Not suitable for forensic analysis.

Race, Sex, and Age Determinations

A strand of hair can be used to fairly accurately determine the race of the person. Where it becomes difficult is when there is a person of mixed races or a person who has severely altered their hair with high volumes of chemicals such as getting frequent perms. In general the following observations can be made:

Caucasoid (European Descent)

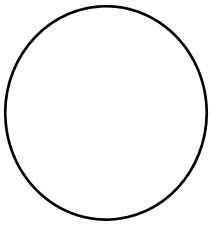
- Hairs will be fine to slightly coarse.
- Hairs will range in color from very light to black.
- Hairs will be generally straight or with slight waves.
- Hairs cross sections will be slightly oval shaped.



Caucasoid Cross Section

Mongoloid (Asian Descent)

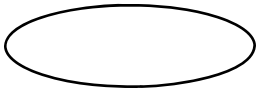
- Hairs will be very coarse.
- Hairs will contain larger pigment granules than Caucasoid hair.
- Hairs will contains a thick medulla.
- Hairs will be straight.
- Hair cross section will be completely round.



Mongoloid Cross Section

Negroid (African Descent)

- Hairs will be medium coarse.
- Hairs will contain the largest pigment granules
- Hairs cross section will be flatter than the other groups.
- Hairs will often have split ends.
- Hair will be kinky or curly due to the flattened cross section.



Negroid Cross Section

Note: The flatter the cross section the curlier the hair.

Age Determination:

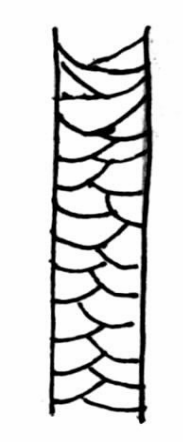
Hairs can not be used to determine the age of a person. The only exception would be a very young baby, who still has soft newborn hair or an older adult that has gray hair.

Sex Determination:

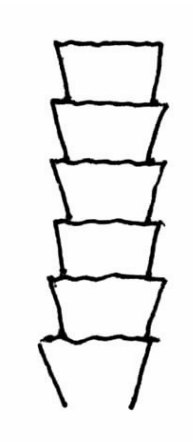
Hairs can not be used to determine the sex of a person. The only exception would be that women often have longer hair and hair that has been treated.

Cuticle Scale Patterns

Hair develops when cells are deposited by the papilla. The manner in which the cells are deposited will determine the scale pattern on the cuticle. Like most other hair factors, scale patterns are a class characteristic. This means that it is possible to determine the species the hair came from but not an individual within that species. While this may not seem important, pet hair has often been used to link a suspect to a crime. For example, if a victim had a German Shepard and a suspect is found to have German Shepard hair on his clothing that would be incriminating evidence, unless he too has a German Shepard. This information alone would not be enough to convict a person, but it would be a good start. Scale patterns have three categories; coronal, imbricate, and spinous. Diagrams of each of the scales is shown below.



Imbricate
Humans



Coronal
Rabbit/Mouse

Spinous
Cat/Fox

Questions To Ask When Examining Hair Evidence

1. What is the probability that the association (or elimination) was due only to coincidence?
2. What is the probability that the association (or elimination) was due to examiner error?
3. What is the probability that there is an alternative explanation for the evidence?

   Examples: a. A secondary transfer

   b. A deliberate planting of evidence

Source: Forensic Science Communications, U.S. Department of Justice, Federal Bureau of Investigation

Forensic Science Hair Analysis Lab

Purpose

This lab will allow you to become familiar with observing hair evidence under the microscope. All of your observations should be recorded in your lab notebook.

Before the lab

You should bring in at least three samples of hair from different people. All the hair should be head hair. In addition, you should bring in at least two samples of animal hair. If you do not have a pet, ask a neighbor or friend. Make sure each sample is in a separate labeled envelope or container.

Procedure

1. Observe the scale patterns of your samples. To do this, place a thin layer of clear finger nail polish on a microscope slide. Allow the polish to become tacky. Place the hair in on the polish. Allow the polish to dry just enough so that the top layer appears to be solidifying. Remove the hair sample. Using a microscope you should see the scale patterns of the hair. Using different areas of one slide, observe the scales of one human hair and two animal hairs. Record your results in your lab notebook.

2. Observe the cross section of hair. To do this take a very thin sheet of clear rubber such as a piece of carpet protector. Using a pin, nail, or very small drill bit, create a very small hole in the rubber. Take several strands of hair, fold them over, shove them into the opening using a pin or small nail. You should have hair sticking out of both sides of the rubber sheet. Using a razor, cut the hair flush with the rubber using a slicing cut (not a pushing cut). Place the sheet under a microscope and observe the cross section. Observe one human hair and two animal hairs using this method. Sketch the diameter shape of the cross section in your notebook.

3. Observe the medulla pattern of hair. To do this place a strand of hair on a microscope slide. Place one or two drops of glycerin or other liquid on the hair to keep the hair in place. Observe the hair under several powers on the microscope. Sketch the results of the best view in your notebook. Observe four different human hairs and four different animal hairs.

4. Calculate the Medullary Index. If you have access to a digital microscope or microscope video camera, you can calculate the medullary index by measuring the width of the medulla and dividing it by the width of the hair shaft. Any unit may be used with these calculations as you are only finding a ratio. There should be no unit labeled in your answer. Show your work with a diagram of the hair calculated in your notebook.

5. Solve the Mystery. Your teacher has five known samples of hair with five unknown samples of hair. Using any or all of the techniques from this lab, determine the correct matches. Show your results in your lab notebook.

The Importance of Fiber Identification in Forensics

Everything around you is made of natural or synthetic fibers. Natural fibers are made from animal or plant materials. These include wool, cotton, camel hair, etc. Synthetic fibers are fibers that are created in the lab. Items such as clothing, carpet, towels, blankets, and building materials all contain different types of fiber. During the course of a crime, it is very likely that some of these fibers may be transferred from one source to another person or object. Since there are so many types and colors of fabric out there, a positive match, although only a class characteristic, can offer a lot of proof in a trial.

The next several pages give information on the most common types of fibers that may be found at a crime scene. Source: Fiber Source at www.fibersource.com

Name/Uses	First U.S. Production	Federal Definition	Production	Properties
Polyester Fiber Clothing, carpets, curtains, drapes, sheets, pillows, wall coverings	DuPont Company 1953	A manufactured fiber in which the fiber forming substance is any long-chain synthetic polymer composed of at least 85% by weight of an ester of a substituted aromatic carboxylic acid.	The most common polyester for making fiber is poly ethylene terephthalate or PET. PET is made by reacting ethylene glycol with either terephthalic acid or its methyl ester in the presence of a catalyst. The reaction is carried out at high temperature and vacuum to achieve the high molecular weights needed to form useful fibers. PET is melt spun.	Strong No shrinking Chemical Resistant Quick Drying Easily washed Wrinkle resistant
Nylon Fiber Blouses, swimwear, carpets, bedspreads, curtains, upholstery	DuPont Company 1939	A manufactured fiber in which the fiber forming substance is a long-chain synthetic polyamide in which less than 85% of the amide-linkages are attached directly (-CO-NH-) to two aliphatic groups.	Molecules with an acid (COOH) group on each end react with molecules with amine (NH_2) groups on each end. A salt is formed, called nylon salt. The salt is heated and dried in a vacuum to eliminate the water and leave only the polymer. The polymer is then melt spun and drawn after cooling.	Very strong Elastic Easily washable Retards moisture Light weight Warmth
Acrylic Fiber Sweaters, socks, fleece, blankets, area rugs, luggage, outdoor furniture	DuPont Company 1950	A manufactured fiber in which the fiber-forming substance is any long-chain synthetic polymer composed of at least 85% by weight of acrylonitrile units $(-CH_2-CH[CN]-)_x$.	Produced from acrylonitrile when it is combined with other chemicals to improve it's performance. The fibers are either wet spun or dry spun to produce the desired effect.	Wickability Flexible Retains shape Easily washed Moth resistant Chemical resistant Fade proof

Name/Uses	First U.S. Production	Federal Definition	Production	Properties
Rayon Fiber Blouses, lingerie, jackets, linings, curtains, upholstery	Avtex Fibers Inc. 1910	A manufactured fiber composed of regenerated cellulose, in which substitutes have replaced no more than 15% of the hydrogen in the hydroxyl group.	In the production of rayon, purified cellulose is chemically converted in a soluble compound. A solution of this compound is passed through the spinneret to form soft filaments that are then converted into almost pure cellulose.	Absorbent Soft Easily dyed Drapes well
Spandex Fiber Hosiery, swimsuits, sportswear, bike pants, surgical hose	DuPont Company 1959	A manufactured fiber in which the fiber forming substance is a long-chain synthetic polymer comprised of at least 85% of a segmented polyurethane.	A cross linked polymer is made. This cross linking prevents molecules from sliding past one another. Therefore, when stress is given then released, the molecules will spring back to their original position with no damage.	Stretchable Strong Lightweight Non Fading

In addition to the synthetic fibers listed above, several common natural fibers are often found at a crime scene. These include cotton, derived from the cotton plant and wool, derived from sheep hair. The characteristics for these two types of fibers would be the same as the general hair characteristics.

Fiber Identification

While understanding the characteristics of fibers is important, of even great importance is to be able to identify the type and source of fibers found on a victim or at a crime scene. There are several means by which a fiber can be identified. The options we will use in our lab investigation use the following methods:

Microscope Analysis

The general shape of the fiber will be observed. This can determine whether the fiber is natural or synthetic.

Cross Section Analysis

Different types of fibers have different cross sectional shapes.

Flame Test Analysis

Some fibers will burn, some will not, and some will only melt. This will help narrow down your choices.

Chemical Test Analysis

-Some fibers will dissolve in certain chemicals while others will not. Using a qualitative analysis scheme, you can narrow down your choices.

Forensic Science Fiber Analysis Lab

Purpose

This lab will allow you to make a set of reference charts that will help you identify fibers. All of your observations should be written in your lab notebook and saved for later reference.

Procedure

1. Obtain several strands of a particular sample. Place a few strands on a microscope slide and place two drops of water on the slide to hold the fiber in place. Record your observations. Make sure you determine whether the fiber is natural or synthetic. Repeat this test will all the other samples.

2. Observe the cross section of the fiber. Obtain a very thin piece of clear rubber, such as a carpet protector overlay. Using a pin, nail, or very small drill bit, create a very small hole in the rubber. Take several strands of fiber, and send them through the opening using a pin or small nail. You should have fibers sticking out of both sides of the rubber sheet. Using a razor, cut the fibers flush with the rubber using a slicing cut (not a pushing cut). Place the sheet under a microscope and observe the cross section. Observe all your samples using this method.

3. Light a candle and place it on your table. Take several strands of each sample and hold them with tweezers. Very slowly move the fibers closer to the flame until they are actually in the flame. You should be observing the reaction of the fibers the entire time they are moving toward the flame. Some fibers will burn only when placed in the flame, while others will burn an inch or two away from the flame. Some will melt into a small, hard bead. Make a data chart in your notebook and record all your results.

4. The next step is to test the solubility of each fiber in different chemicals. A material is said to be soluble if it dissolves in a given substance. There are several different lines of each type of fiber manufactured. Each line may be manufactured a slightly different way giving it unique properties. Below is a listing of several solubility assumptions based upon work done by Rose Padget of Southern Illinois University.

    A. Concentrated acetic acid that is brought to boiling will dissolve acetate and nylon.

    B. Concentrated acetone at room temperature will dissolve acetate.

    C. 5% boiling sodium hydroxide will dissolve natural fibers.

    D. 45% boiling sodium hydroxide will dissolve natural fibers and acetate.

    E. 50% hydrochloric acid will dissolve nylon

    F. 60% sulfuric acid will dissolve rayon, acetate, and nylon

    G. 70% sulfuric acid will dissolve rayon, acetate, nylon, and cotton.

To test the solubility of your fibers, place several fibers in a small culture tube. Add a few milliliters of solvent and agitate the solution for several minutes. If the solvent needs to be boiling, heat the solvent with a Bunsen burner. Conduct this test with five fiber samples and record your results in your lab notebook. Use any of the solvents that you deem necessary but be sure not to use all of your sample as you will probably have to conduct other tests.

5. Solve the mystery. Obtain five unknown fiber samples from your teacher. Using your notes you took during this lab, identify the type of fiber each sample contains. Record your findings in your lab notebook.

Interactive Case Study: The Wayne Williams Murders

On a late evening in July 1979, a fourteen year old boy left a skating rink in Atlanta, Georgia after a date and headed home. The boy never made it home from the skating rink, instead his body was found one week later in a wooded area in the southern part of Atlanta. Another boy was found with him that had also been missing about a week.

Not much thought was given to the crimes as both boys lived in a poor inner-city area, where crimes are not that uncommon. It was thought that both African American boys were probably partying together with drugs and overdosed or got into a fight. Soon after these bodies were found another young African American male was found murdered in the same area. One young African American male after another was found murdered or missing in the same area of Atlanta. This finally got the attention of the community and they demanded the police solve the murders. Investigators began mapping out victims, and came up with one of the first uses of criminal profiling. They thought that the killer was familiar with his surroundings and was also African American. This angered much of the community.

Forensic investigators had begun to gather trace evidence from each of the victims. Almost all of the victims had very similar green fibers on their clothing and hair. Some also had very similar dog hairs attached to their clothing. The media reported this finding and criminal profilers expected that the killer would try to find a way to eliminate the fibers from the bodies. Sure enough, just a few days later, the next victim was found nude in the river. While there were fewer fibers found on this victim, some were still found in the victim's hair. While this loss of evidence may seem negative for the investigators it allowed them to start narrowing down where the bodies will be dumped. On May 22, 1981 police were staked out under the James Jackson Parkway Bridge, which spanned the Chattahoochee River. This is the river were several other bodies had been found. After midnight one of the officers heard a loud splash and saw that a car was stopped on top of the bridge. After this car was followed for a while, it was pulled over and Wayne Williams was inside. This 23 year old African American male said he was a photographer as was lost trying to get to a person's home. Police did not believe his story as the number and address for the person he was trying to reach was wrong. While the police still had suspicions, he was let go after police could not find a body in the river.

Eventually the F.B.I. and the police began investigating Williams further and started finding fiber matches between the fibers and hairs found on the victims and those found in Williams' home. This led to his arrest on June 21, 1981.

There were quite a few victims of this case and trying to tie them all together would be very difficult. They decided to focus on twelve of the victims that could most likely be connected with Wayne Williams. In January of 1982 Wayne Williams was found guilty for two of the murders (the only two tried at that time) and was sentenced serve two life sentences.

Many African Americans were upset by the verdict because they believed the government planted much of the evidence in this case. They did not believe that an African American would kill other African Americans. Truth is that most serial killers will kill within their own race. It would have been very unlikely that a while serial killer would have killed African Americans. Ted Bundy, a white serial killer killed only white females. A St. Louis African American serial killer was found to have killed only African American prostitutes in East St. Louis. An exception to this is the Washington D.C. Sniper. Those shootings do not seem to aim at any one particular type of person.

Atlanta Child Murder Investigation

The entire case against Wayne Williams hinged on the hair and fiber evidence found on all the victims. Investigators believed that he murdered 29 African American males. Twelve of those victims are listed below. Your teacher has samples of hair and fibers that are known to belong to Wayne Williams. In addition, you will be given a vial of fibers found on each of the victims below. It is your job to determine the source of each of the fibers by comparing them to the known samples. When a match is found, place an "X" in the appropriate box. Your observations and findings should be documented in your lab notebook.

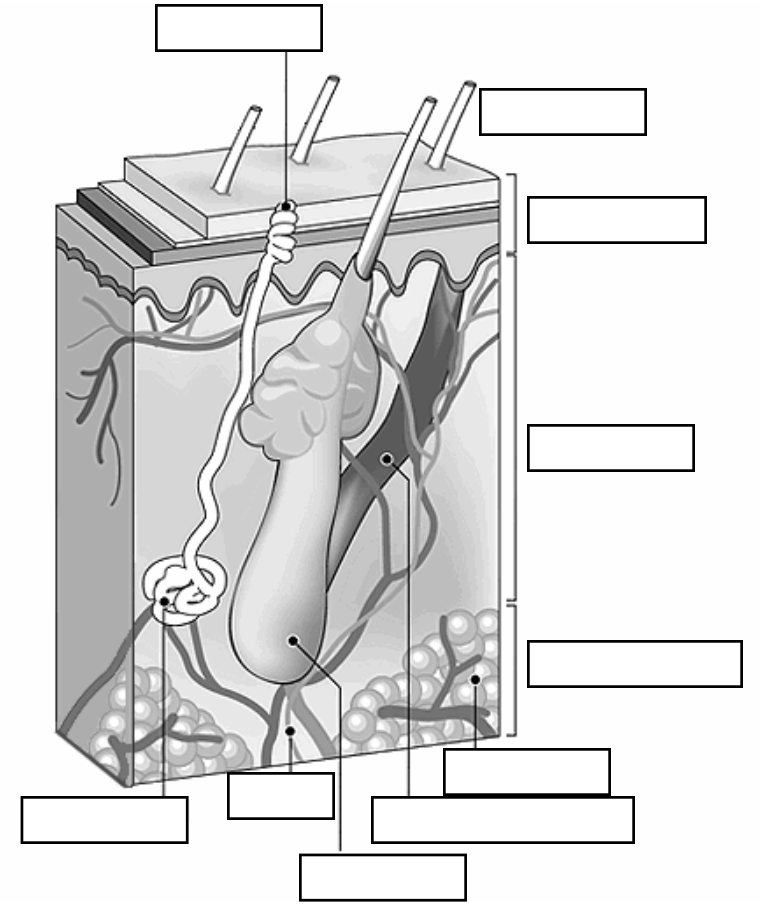
Note: Be very careful with your fibers. One exhaling of hair, a cough, or a sneeze will quickly sweep away any unprotected fibers.

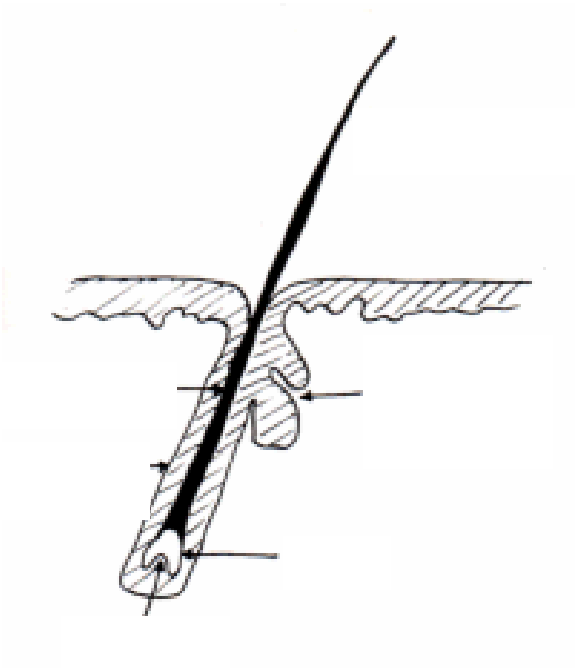
Wayne Williams Evidence Table

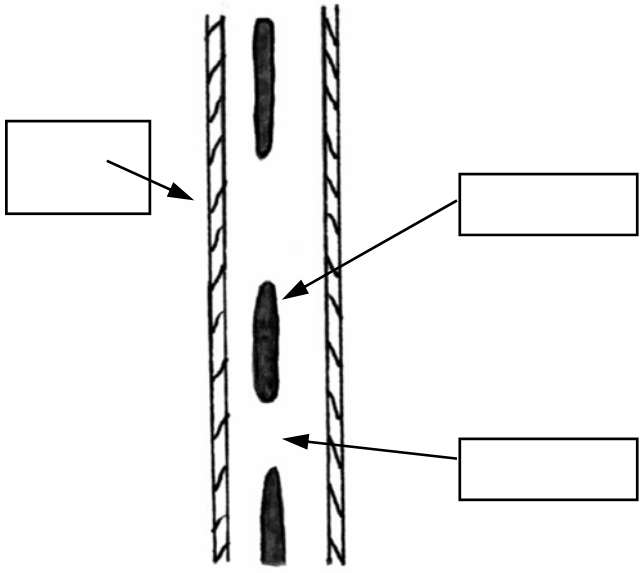
Victim Name & Age	Cause of Death	Suspect Bedspread	Suspect Bedroom Carpet	Suspect Dog Hair	Suspect Blanket	Suspect 1979 Ford Carpet	Suspect 1970 Chevy Carpet
Alfred Evans, 13	Asphyxiation						
Eric Middlebrooks, 14	Trauma to head						
Charles Stephens, 10	Asphyxiation						
Lubie Geter, 14	Strangulation						
Terry Pue, 15	Strangulation						
Jimmy Payne, 13	Strangulation						
Patrick Baltazar, 12	Strangulation						
John Porter, 16	Strangulation						
Joseph Bell, 16	Asphyxiation						
Larry Rogers, 20	Strangulation						
Nathaniel Carter, 28	Asphyxiation						
William Barrett, 17	Strangulation						

Review Questions for Hair & Fiber Unit

1. Fill in the anatomical parts of the diagrams below.







2. What value does hair and fiber evidence have in an investigation?

3. An investigator suspects that a victim has been poisoned for six months. Beginning at the root tip, how many inches will the poison be detected in the hair shaft?

4. List and explain the three stages of hair growth. Draw a diagram of what hair will look like when pulled from the active and dormant stages. Which is more important for forensic investigators and why?

5. List and draw a diagram of the three types of scale patterns and the three types of medulla patterns.

6. What questions should be asked when examining hair for evidence?

7. Outline the differences between Cacasoid, Mongoloid, and Negroid hair samples.

8. Can hair give any clues to the age and sex of a person? Explain why or why not.

9. What are the four tests commonly used to identify a particular piece of fabric?

10. A fiber will dissolve in concentrated acetic acid, but not in 50% hydrochloric acid. What type of fiber could this be?

11. What is the difference between natural and synthetic fibers? Give two examples of each.

12. How did giving investigation information in the Wayne Williams case to the media actually help the investigators?

Notes