Unit 2: Hair and Fibers

Objective 1: Examine and analyze the forensic aspects of hair.
1. Describe Locard’s Exchange Principle and how it applies to hair and fiber analysis.
2. Describe the microscopic structure of hair (shaft, root, and follicle).
3. Describe the general biological make-up and function of hair (shape, growth, and function).
4. Describe how hair and fiber evidence is used in forensic science.
5. Compare and contrast a variety of hair samples from different human races and different types of animals.

Objective 2: Examine and analyze the forensic aspects of fibers.
1. Identify and compare natural and synthetic fiber types by using physical (microscopic) testing methods.
2. Describe the general procedures and purpose for chemical testing methods to identify synthetic fibers.
3. Compare and contrast common fiber weave patterns (plain, twill, satin, knitted).
4. Summarize systematic procedures for collection and identification of hair and fiber evidence.
5. Explain the general procedures of chromatography and how it is used to identify dyes used to color fabric.

Key Terms:
- Hair shaft
- Hair cuticle
- Hair cortex
- Hair medulla
- Coronal scales
- Spinous scales
- Imbricate scales
- Hair root
- Hair follicle
- Anagen phase
- Catagen phase
- Telogen phase
- Fiber
- Fabric
- Yarn
- Warp
- Weft
- Blend
- Synthetic Fiber
- Natural fiber
- Plain Weave
- Twill Weave
- Satin Weave
- Knitted Weave
- Primary transfer
- Secondary transfer
- Luster
- Chromatography

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</table>
Objective: Students will be able to describe Locard’s Principle and how it relates to hair and fiber analysis.

Warm-Up:
1. When is your unit assessment?
2. What are two things that I want you to know by the end of this unit?

Locard’s Exchange Principle and Microscope Review

Locard’s Exchange Principle

- The value of trace (or contact) forensic evidence was first recognized by Edmund Locard in 1910. He was the director of the very first crime scene laboratory in existence, located in Lyon, France.
- Locard’s Exchange Principle states that “with _____________ between two items, there will be an __________.” In other words: “Every contact leaves a trace!”
- Examples of things that can be transferred:
  - Paint
  - Glass
  - Traces of chemicals used in explosives
  - Characteristics of ammunition, firearms, and chemical residue
  - Dust and dirt particles
  - Fingerprints
  - Impression Evidence: shoe prints, tire tracks, bite marks, tool marks
  - Fracture matches when an object is broken
  - The shape and depth of a wound
  - Documents
  - Insects
  - DNA
  - Body Fluids
  - Hair and Fibers

Microscope Review

Microscope Parts:
- Eyepiece
- Body Tube
- Revolving Nosepiece
- Objective Lens
- Stage Clips
- Stage
- Diaphrag
- Light
- Arm
- Coarse Focus
- Fine Focus
- Base
Using the Microscope: General Procedures

1. Make sure all ______________ and materials are out of the aisles and off the tops of desks.
2. ______________ your microscope in to the outlet.
3. Store with ______________ wrapped around microscope and the scanning objective lens clicked into place.
4. Carry by the base and arm with ______________ hands.

Magnification

- Your microscope has ______________ magnifications: Scanning, low and high. Each objective lens will have written the ______________. In addition to this, the ocular lens (eyepiece) has a magnification. The total magnification is the ______________ X ______________.

<table>
<thead>
<tr>
<th>Magnification</th>
<th>Ocular lens</th>
<th>Total Magnification</th>
</tr>
</thead>
<tbody>
<tr>
<td>Scanning</td>
<td>4x</td>
<td>10x</td>
</tr>
<tr>
<td>Low Power</td>
<td>10x</td>
<td>10x</td>
</tr>
<tr>
<td>High Power</td>
<td>40x</td>
<td>10x</td>
</tr>
</tbody>
</table>

Focusing Specimens

1. Always start on the ______________ power (scanning lens). Move the slide around until you see something in the lens. Use the ______________ adjustment knob to refocus. Then use the ______________ Adjustment Knob to make the image crystal clear. If you don’t focus on this level, you will not be able to move to the next level.
2. Now switch to a ______________ power. (If you have a thick slide, or a slide without a cover, do NOT use the highest power objective lens). At this point, ______________ use the Fine Adjustment Knob to focus specimens.

- Recap
  1. Lower power → use course and fine knob.
  2. High power → use fine adjustment knob only
    **Do not skip steps!**

Troubleshooting

- Occasionally you may have trouble with working your microscope. Here are some common problems and solutions.
  1. Image is too dark! Adjust the ______________, make sure your ______________ is on.
  2. There’s a spot in my viewing field, even when I move the slide the spot stays in the same place! Your lens is dirty. Use ______________, and only lens paper, to carefully clean the objective and ocular lens. The ocular lens can be removed to clean the inside. The spot is probably a spec of dust.
  3. I can’t see anything under high power! Remember the steps! If you can’t focus under scanning and then low power, you won’t be able to focus anything under high power. ______________ at scanning and walk through the steps again.
  4. Only half of my viewing field is lit, it looks like there’s a half-moon in there! You probably don’t have your objective lens fully clicked into place.
How to Create a Wet Mount Slide

1. Using a pipet or dropper, add a ____________of water to a clean microscope slide.
2. Place your ____________in the water.
3. Hold the coverslip at a ____________angle to the slide.
4. Place the ____________of the coverslip on the slide so that it touches the edge of the water.
5. Slowly lower the coverslip to prevent the formation of air ________________.

9/11/18

Objective: Students will be able to describe Locard’s Principle and how it relates to hair and fiber analysis.

Warm-Up:

1. A man broke into a car last weekend and took it for a joy ride with his buddy. Police found the car and took it to the lab for processing. A witness called the investigator and said that she thinks she saw her next-door neighbor in the car on Saturday night. What type of trace evidence would you look for in the vehicle to try and prove that the suspect was in the car?

9/12/18

Objective: Students will learn about the job of a coroner and how it relates to forensics from a guest speaker.

Warm-Up: None

9/13/18

Objective: Students will be able to describe the microscopic structure of hair and the general biological make-up and function of hair.

Warm-Up:

1. Why is Locard’s Principle really important in forensics?

2. What did you look at under the microscope yesterday? What surprised you? What was interesting?
Structure and Function of Hair

Structure

- Hair is an appendage of the skin that grows out of an organ known as the_______________.
- A hair is made up of three general parts:
  1. Follicle
  2. Root
  3. Shaft
- Label the diagram of the hair below.

Structure (cont.)

1. ______________________-tube like organ in the under layer of the dermis and is linked to the body’s blood supply.
   a. ______________________-indention of follicle where blood vessels, nerves enter and exit
   b. Matrix-are of cell division and hair growth.
2. ______________________-portion of hair below the skin, embedded in the follicle
3. ______________________-portion of hair above the surface of the skin, made up of three layers.
   a. Cuticle-clear outside covering of the shaft, made up of overlapping scales. There are three basic ______________________that make up the cuticle. Combinations and variations of these types are possible.
      i. Corona-crown-like, found in small rodents and bats, rarely in humans
      ii. Spinous-petal-like, found in seals, cats, and some animals never humans
      iii. Imbricate-flattened, found in humans and animals
      iv. Label the scale patterns below.

   b. ______________________-made up of keratin molecules, the pigment that gives hair its color.
c. __________-row of cells running along the center of the cortex which may appear dark or translucent depending on the presence of air, liquid, or pigment.

i. Can be fragmentary, interrupted, continuous, or stacked.

<table>
<thead>
<tr>
<th>Medulla Type</th>
<th>Picture</th>
</tr>
</thead>
<tbody>
<tr>
<td>Solid</td>
<td>![Solid Medulla Image]</td>
</tr>
<tr>
<td>None</td>
<td>![None Medulla Image]</td>
</tr>
<tr>
<td>Fragmentary</td>
<td>![Fragmentary Medulla Image]</td>
</tr>
<tr>
<td>Continuous</td>
<td>![Continuous Medulla Image]</td>
</tr>
<tr>
<td>Stacked</td>
<td>![Stacked Medulla Image]</td>
</tr>
<tr>
<td>Interrupted</td>
<td>![Interrupted Medulla Image]</td>
</tr>
</tbody>
</table>

ii. May not be visible in human hair.

iii. In animals, it is at least _______ of the diameter of the hair.

iv. _________________ is the quickest way to determine a hair's origin in terms of human or non-human.

1. Hair is 3-D and of a circular nature
2. A circumference is the distance across a circle
3. If the circumference of the medulla is less than 1/3 (33%) of the circumference of the entire shaft, then it is most likely of human origin.
4. If the circumference of the medulla is greater than 1/3 (33%) of the circumference of the entire shaft, then it is most likely of animal origin.

General Biological Make-Up of Hair

- Shapes of Hair
  - _________________-straight hair
  - _________________-curly hair
  - _________________-kinky hair

- Growth: there are 3 stages:
  - Anagen phase-______________ phase, averaging three to five years for scalp, 30-45 days for parts of the body, hair grows about 1cm a month.
Catagen phase—_________________ period of hair growth, lasting 2-3 weeks, outer sheath shrinks to the root forming club hair, 3% of all hair at any one time
Telogen phase—_________________ phase, 10-15% of all hair, lasts about 100 days for scalp and longer for other parts of the body, club hair fully formed.

General Function of Hair

- ___________________________
  - Guards the scalp from injury and sunlight
  - Eyebrows and eyelashes protect the eye
  - Hair in ears and nostrils keep out foreign objects
- Helps regulate ___________________
- ___________________________ associated with hair follicles

9/14/18

Objective: Students will be able to describe how hair analysis is used in forensic science.

Warm-Up:

1. Label the cuticle, cortex, and medulla in the following shaft of hair.

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[Image of a shaft of hair with labels for cuticle, cortex, and medulla]
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2. In the following picture, determine if the cuticle has a corona, spinous, or imbricate shape.

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[Figure 10: Types of animal hair]
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Purpose for Hair Analysis

Why do we want to analyze hair?

- The presence of hair often denotes ___________________________ between a suspect and a victim, and usually means it's a crime of a serious or violent nature.
- It can provide strong ___________________________ evidence for placing a suspect at a crime scene.
- The first step in an analysis is to compare the _________________ structure, origin (human or animal) and if warranted, a more detailed DNA analysis.
- Purpose:
  - To determine if the hair is human or animal
  - If animal, what _________________?
  - If human, who it belongs to (a suspect, victim, or other)?

When comparing hairs, look for:

- A match in _________________, length, and diameter
• Presence or absence of a ______________
• Distribution, shape, and color intensity of the ______________ granules in the cortex.
• Dyed or bleached hair (can determine amount of time between dye jobs)
• Morphological abnormalities due to certain diseases or deficiencies
  o Can see ______________, heavy metal poisoning, and environmental factors like certain types of pollution.
• Fungal or bug infections

A Note of Caution

• There is a lot of ______________ in human hairs so we must be very cautious when comparing human hairs.
• Because of so much variation, most human hair analysis should be backed up with ____ analysis if possible.

What can we determine with hair samples?

1. Location on the body which a hair originated
   a. ______________: little diameter variation, more uniform distribution of pigment.
   b. ______________: short and curly, wide variety of diameter variation, continuous medullae.
   c. ______________: course texture, triangular in cross section, blunt tips acquired from cutting or shaving.

2. Human or Animal
   a. Root differences:
      i. Human:
         1. ______________: bulblike shape with few, if any, pigment granules
         2. Mature hair ______________ from scalp: may have follicular tissue attached and may look stretched, there may be pigment granules since the hair was still growing.
      ii. Animal
         1. Generally, ______________ shaped
   b. Pigment differences:
      i. Human: generally ______________ in color and pigmentation throughout the length of the hair shaft, the distribution of pigment granules is evenly distributed or slightly denser towards the cuticle.
      ii. Animals: can have ______________ -a radical change in color in a short distance, the distribution of pigment granules is more centrally distributed and denser toward the medulla.
   c. Other differences:
      i. Different scale structure, medullary index, and medullary shape

3. Racial Origin-risky to assign racial characteristics, but some generalizations can be made
   a. ______________
      i. Shaft diameter: moderate with minimal variation (mean diameter for human head hairs – 80um)
      ii. Pigment granules: sparse to moderately dense with fairly even distribution
      iii. Cross-sectional shape: oval
b. ______________________
   i. Shaft diameter: moderate to fine with considerable variation
   ii. Pigment granules: densely distributed (hair shaft may be opaque) and arranged in prominent clumps.
   iii. Shaft: prominent twist and curl
   iv. Cross-sectional shape: flattened

c. ______________________
   i. Shaft diameter: course and usually with little or no variation
   ii. Pigment granules: densely distributed and often arranged in large patchy areas or streaks
   iii. Medulla: prominent (often broad and continuous)
   iv. Cuticle: thick
   v. Cross-sectional shape: round

4. Whether the hair was forcibly removed or fell out
   a. Hair root
      i. Pulled out by force or brushing: usually has _____________ tissue still attached
      ii. Naturally falling out: _____________-shaped root with no adhering tissue

5. DNA Analysis
   a. If follicular tissue is present: we can get _____ from the nucleus
      i. Better success rate of getting DNA from hairs in the _____________-phase of growth
      ii. Hairs in the _____________-phase of growth have an inadequate amount of DNA
         1. Since most hairs are in this phase, it is not likely to get a match from a hair at a crime scene
         2. The exception is if the hair was forcibly removed.

6. Mitochondrial DNA analysis
   a. Used when there is ______________________ attached to the hair
   b. Mitochondrial DNA is found in the ________________of cells and gets passed down from our ________________
   c. Because this DNA is found in the mitochondria, it is much more prevalent in our cells than nuclear DNA. Therefore, it is much more likely to be extracted for analysis than nuclear DNA.
   d. The downside to mitochondrial DNA analysis is that it cannot tell the difference between ________________that have the same mother.

What Can’t We Determine with Hair Samples?

- _____________ and _____________of an individual
- Personal identification
  o We have to use either DNA analysis or Mitochondrial analysis.
9/17/18

Objective: Students will be able to identify if a hair is human or animal and be able to describe the characteristics that led to the identification of a hair.

Warm-Up:

1. Determine if the following hairs are human or non-human based on medullary index.

9/18

Objective: Students will be able to identify if a hair is human or animal and be able to describe the characteristics that led to the identification of a hair.

Warm-Up:

1. What did you notice about the root of a hair that was pulled out of the head versus a root of a hair that fell out naturally? What might this tell you about what happened?

2. What did you notice about the end of the hair that was cut versus broken? What might this tell you about what happened?

Vocabulary Scramble: Use the definition to unscramble the vocabulary word. (7 words on the next page)

<table>
<thead>
<tr>
<th>Vocabulary Word</th>
<th>Scrambled Word</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>rhia emdlula</td>
<td>A row of cells running along the center of the shaft.</td>
<td></td>
</tr>
<tr>
<td>ahri oclfliel</td>
<td>Tube like organ in the under layer of the dermis and is linked to the body’s blood supply.</td>
<td></td>
</tr>
<tr>
<td>gactnae hspae</td>
<td>The intermediate phase of hair growth where the outer sheath shrinks.</td>
<td></td>
</tr>
<tr>
<td>ahri xotcre</td>
<td>The middle layer of the hair shaft, made up of keratin molecules and pigment.</td>
<td></td>
</tr>
<tr>
<td>inssopu ceals</td>
<td>Scale pattern that looks petal-like.</td>
<td></td>
</tr>
<tr>
<td>Term</td>
<td>Description</td>
<td></td>
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<tr>
<td>---------------------------</td>
<td>-----------------------------------------------------------------------------</td>
<td></td>
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<tr>
<td>ihra sthaf</td>
<td>Portion of the hair above the surface of the skin, made up of three layers.</td>
<td></td>
</tr>
<tr>
<td>hria orto</td>
<td>Portion of the hair below the skin that is embedded in the follicle.</td>
<td></td>
</tr>
<tr>
<td>eleogtn hspae</td>
<td>The resting phase of hair growth, where the hair spends the majority of its life.</td>
<td></td>
</tr>
<tr>
<td>ibticmare classe</td>
<td>Scale pattern where the layers are flattened against each other.</td>
<td></td>
</tr>
<tr>
<td>ihra Iticceu</td>
<td>The clear outer covering of the hair shaft, made up of overlapping scales.</td>
<td></td>
</tr>
<tr>
<td>gaanne hesap</td>
<td>The active phase of hair growth where hair is growing about 1 cm per month.</td>
<td></td>
</tr>
<tr>
<td>aornlco cealss</td>
<td>Scale pattern that looks crown-like.</td>
<td></td>
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</tbody>
</table>

9/19/18

**Objective:** Students will be able to describe the difference between a natural and synthetic fiber and be able to compare and contrast common weave patterns.

**Warm-Up:**

1. What is the difference between a fragmented versus an interrupted medulla?

2. What is the difference between a continuous versus a solid medulla?

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**Introduction to Fibers**

**What is a Fiber?**

- A ________________ is the smallest unit of textile material that has a length many times greater than its diameter.
- A fiber can be spun with other fibers to form a ________________ that can be woven or knitted to form a ________________.
- The type and length of fiber used, the type of spinning method, and the type of fabric construction all affect the transfer of fibers and the significance of fiber associations.

**Types of Fibers**

- ________________: come wholly from animal, plant, and mineral sources.
  - Animal: sheep (wool), goats (mohair, cashmere), camels, llamas, alpacas; fur from: mink, rabbit, beaver, muskrat, etc.
  - Plant: cotton, flax, hemp, bamboo
  - Mineral: asbestos, rock wool, fiberglass
• **Polymers**: formed by linking a large number of single molecules, called monomers, together in a chain.
  - Acetate, nylon, polyester, rayon, spandex

**Characteristics of Fibers**

• Natural fibers have ________________ in shape, twisting, edges which are not smooth or scale patterns (wool), etc.
  - Cotton-flattened tubes, twisted and bent
  - Silk-tubular, doesn’t twist much
  - Wool-looks like animal hair, overlapping scales
  - Linen-plant fiber

• Synthetic fiber-smooth forms, ________________ shapes along the entire strand. The shapes are produced by machines.

**Filament Cross Sections**

• Synthetic fibers are forced out of a ________________ 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 ________________ shape in cross section.

![Cross Section Diagram]

**Fabric Production**

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

**Weave Terminology**

1. ________________ - a continuous strand of fibers or filaments that may be twisted together.
2. ________________ - lengthwise yarn
3. ________________ - crosswise yarn
4. ________________ - a fabric made up of two or more different types of fibers
Weave Patterns

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

- The warp yarn is passed over one to three weft yarns before going under one.
  - Makes a diagonal weave pattern.
  - Design resembles stair steps.

- The yarn interlacing is not uniform
  - Creates long floats
  - Interlacing weave passes over four or more yarns

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

What is the Significance of Fiber Evidence?

- Can provide evidence that there is contact between __________ individuals.
- Can provide evidence that there is contact between an __________ and an __________.
- Very useful when the comparison is to ________________, like the carpet in the trunk of a specific car.
- Should be used in conjunction with other evidence-very rare to get a conviction based on only fiber evidence.
- Value is dependent on:
  - Type of fiber
  - Color or color variations in the fiber
  - Location of the fiber
  - Number of fibers that match between a victim and a suspect.

Problems with Fiber Evidence

1. Class Characteristic
a. ____________________________ of goods/garments
2. The less common the fiber, the more useful it is to identify a suspect.
   a. ____________________________ : very common-basically meaningless in forensic investigations

9/20/18

Objective: Students will be able to describe the difference between a natural and synthetic fiber and be able to compare and contrast common weave patterns.

Warm-Up:

1. What is the difference between natural fibers and manufactured fibers?

2. What are some examples of natural fibers? Manufactured fibers?

9/21/18

Objective: Students will be able to summarize the systematic procedures for the collection of hair and fibers and describe the general procedure and purpose for chemical testing methods to identify synthetic fibers.

Warm-Up:

1. Determine if the following fibers are natural or synthetic. Briefly explain why you identified them the way you did.

Identifying Fiber Samples

Fiber as Trace Evidence

• ____________________________ : occurs when fibers are transferred from a fabric directly onto a victim’s clothing.
• ____________________________ : occurs when already transferred fibers on the clothing of a suspect transfers to clothing of a victim.
• Important for reconstruction of crime scene.
Using Fibers to Reconstruct Crime Scenes

1. The ________________ of the garment/fiber
2. The ________________ and composition of the fabric.
3. Mobility of the victim
   a. The ________________ movement, the more likely ________________ will be transferred.
4. The length of time between actual physical contact.
   a. Likelihood of finding transferred fibers on the clothing of the suspect __________ after each day that passes.

Collecting Fibers

• Identify ________________ where fiber transfers likely occurred
• Try to ________________ the evidence in the ________________ location for transport to the lab
  o Ex: car seats are covered in a polyethylene sheets for transport
• If you have to collect it, do so carefully!
  o ________________: fold and package in different paper bags - each piece gets its own bag. Bag directly from source.
  o ________________: fold and place in their own bag.
  o ________________: cover before placing in a paper bag.
  o ________________: removed with forceps, folded in a piece of paper, and placed in a paper bag.
  o Make ________________ of exposed skin areas and any inanimate objects.

Identification of Fibers

• Visual Inspection
  o ________________ of the fiber
  o ________________ or lack of luster
  o Body, texture, hand
    ▪ Soft to hard, rough to smooth, warm to cool, stiff to flexible
• Microscopic Observation
  o ________________: look at the shape, twisting, edges, scale pattern, etc.
  o ________________: positive identification is not possible but you can look at some basic characteristics like: weave of the fabric and cross sectional shape of the fibers.

Chemical Tests of Synthetic Fibers

1. ________________: observation of how a fiber burns, the odor, color of flame, color of smoke, and the appearance of the residue
2. ________________: gently heating to break down the fiber to the basic monomers
3. ________________: solubility and decomposition
4. ________________: the mass of an object divided by the volume of the object
5. ________________ - measurement of the bending of light as it passes from air into a solid or liquid
6. ________________ - absorption and reemission of light; used for comparing fibers as well as spotting fibers for collection.

Dyes

1. Components that make up dyes can be separated and matched to an unknown.
2. There are more than ________________ different dye formulations.
3. ________________ is used to separate dyes for comparative analysis.
4. The way a fabric accepts a particular dye may also be used to identify and compare samples.

Basic Comparison of Fiber Samples

1. Visual inspection: color, texture, luster
2. Microscopic:
   a. ________________
   b. ________________
      i. Natural: what type of fiber
      ii. Synthetic: cross section of fibers, lengthwise striations, diameter

9/24/18

Objective: Students will be able to identify and compare natural and synthetic fiber types using the microscope to examine fibers.

Warm-Up:

1. Label the warp and weft fibers in the following diagrams.

   plain  twill  satin

9/25/18

Objective: Students will use chromatography to identify dye in materials.

Warm-Up: (2 Questions)

1. What characteristics did you look for yesterday when you were identifying the type of fiber as natural or synthetic?
2. Why is cotton a useless fiber to find at a crime scene? What would be a better fiber to find at a crime scene? Why?

9/26/18

Objective: Students will demonstrate their knowledge of hair and fibers on a unit review.

Warm-Up:

1. Go back to the front page of this packet and read the objectives. Put a question mark next to the ones you are still unsure about. Put a star next to the ones that you know.
2. How are you going to study for the objectives that you are unsure about?

9/27/18-9/28/18

Objective: Students will apply their knowledge of Locard’s Principle to match trace evidence, like hair and fibers, to their daily activities.

Warm-Up:

1. None

10/1/18

Objective: Students will demonstrate their knowledge of hair and fibers on a unit test.

Warm-Up:

1. Turn your work in to the basket.