Trace Evidence: Hair and Fiber

**Course**
Forensic Science

**Unit VI**
Forensic Hair & Fiber Analysis

**Essential Question**
What are the differences between class characteristics and individual characteristics?

**TEKS**
§130.295(c)
(1)(A)(B)
(2)(F)(G)(H)
(3)(A)(D)(E)(F)
(6)(G)(H)
(7)(B)(C)(D)

**Prior Student Learning**
- Crime Scene Investigation
- Locard’s Exchange Principle

**Estimated Time**
- 3 days Lecture
- Two 45-minute hair microscopy labs
- Two 45-minute fiber labs

**Rationale**
Trace Evidence examination is often challenged in court for its uncertainty. Nonetheless, characterization of hair and fiber evidence has played an important role in providing investigative leads in many criminal cases. It is not to be replaced in its entirety by DNA analysis, but to be used complimentarily with other disciplines and technology in forensic science.

**Objectives**
The student will be able to:
1. Identify the racial and somatic origin of unknown hairs based on their characteristics
2. Distinguish between human and animal hairs
3. Distinguish between natural and synthetic fibers
4. Examine the subtle differences between questioned and known samples of hairs and fibers

**Engage**
Do an Internet search for an article using the following: Ted Bundy Rachel Bell. Read the article as a class and discuss the role that hair and fiber trace evidence played in the capture and conviction of Ted Bundy. Use the Discussion Rubric for assessment.

**Key Points**
I. Hair is a slender, threadlike outgrowth from follicles of the skin of mammals. Hair is found all over the body: head, face, chest, limbs (arms and legs), and the pubic region.
   A. Major constituents of hair
      1. Keratin is a protein that makes up most of the hair shaft.
      2. Melanin is a pigment that gives hair its color.
      3. Redheads have pheomelanin instead of melanin.
   B. The structure of a hair can be compared to a number 2 pencil.
      1. The cortex is the main body of a hair (compared to the wooden portion of a pencil)
      2. The medulla is the central cell of the cortex (compared to the lead of a pencil). The medulla is not present in every hair.
      3. The cuticle is a layer of scales covering the hair shaft (compared to a layer of yellow paint on a pencil).
      4. The root is also known as the “proximal end” (compared to the eraser on a pencil).
      5. The tip is also known as the “distal end” (compared to the sharpened tip of a pencil).
   C. Characteristics used in hair comparison
      1. Pigment colors (light, medium, dark, reddish-brown, brown, black, etc.)
      2. Pigment sizes (fine, moderate, large)
      3. Pigment density (light, moderate, heavy)
4. Pigment distribution (random, peripheral, even, central, one-sided)
5. The presence, location, and level of an abundance of ovoid bodies (spheric to oval solid structures mostly found in cattle and dog hairs, but present in some human hairs)
6. The presence, location, and level of an abundance of cortical fusi (elongated spindle-shaped air spaces in the cortex)
7. The presence of special characteristics (cuticle damage, artificial treatment)

D. Stages of hair growth are determined by the proximal end (root).
   1. An anagen root indicates an active growth stage. It is often found with a ribbon-like tip and a follicular tag (a soft tissue from the follicle).
   2. A catagen root indicates the intermediate growth stage.
   3. A telogen root indicates a resting stage, and has a bulb-like shape. It is often found with very little pigment and an abundance of cortical fusi.

E. Hairs that are forcibly removed often end up with a follicular tag attached to the roots. The follicular material may be suitable for nuclear DNA analysis for individual identification.

F. A postmortem root band (or a Dead Man’s root) is a dark band that may appear near the root of the hair originating from a decomposing body.

G. Finding such evidence in the trunk of a suspected vehicle strongly indicates that a dead body was once there (perhaps during the transportation of the body to another location).

H. Variations in the distal end (tip) include
   1. Scissor-cut distal
   2. Abraded
   3. Razor-cut
   4. Rounded
   5. Broken
   6. Burnt

I. Three main differences between Human and Animal hairs
   1. Pigments
      a. Human hair pigments remain consistent in their color and pigmentation throughout the length of the hair shaft.
      b. Animal hair pigments often exhibit rapid and radical color changes.
   2. Medulla
      a. Human hair medullae are thin and take up no more than 1/3 of the hair shaft diameter. They appear amorphous.
      b. Animal hair medullae are very wide and take up almost the entire shaft diameter. They appear very regular and well-defined, with different patterns indicating different species.
   3. Scale structures
      a. Human hairs have overlapping imbricate scales with narrow margins.
      b. Some animal hairs may have imbricate scales, coronal (crown-shaped) scales, or spinous (petal-shaped) scales.

J. Racial characteristics– most human hairs can be classified into one
of the three racial origins:
1. Caucasian hairs exhibit moderate shaft diameter with very little variation. They are light to moderate in pigment density with fairly even distribution. Their cross-section may be oval in shape.
2. Mongoloid hairs exhibit coarse shaft diameter and streaky pigments with heavy density. They have thick cuticles and a round cross-section.
3. Negroid hairs exhibit fine to moderate shaft diameter with prominent twists and curls. They have heavy pigment density with aggregate clumping. They have a flat cross-section.

K. Somatic origin – hairs from different parts of the body exhibit different characteristics
1. Head hairs are typically longer than other hairs of the body. They are generally soft, and are the most likely to have artificial treatments.
2. Pubic hairs are typically coarse in diameter, with wide variations. Buckling is a special characteristic found in pubic hairs.
3. Limb hairs tend to be fine and arc-like. Their tips are usually tapered or abraded.
4. Facial hairs are very coarse with irregular or triangular cross-sections. Their medullae may be very broad, even double.

L. Animal hairs – classified into three (3) major groups by microscopic appearance:
1. Deer and antelope family are distinguished by their isodiametric scales and wineglass-shaped roots.
2. Commercial fur animals, such as rabbits and minks, are distinguished by their banded, serial ladders or vacuolated medulla structures.
3. Domestic animals are distinguished by their amorphous medullae and characteristic root shapes.

M. Diseases or deficiencies may result in changes in the appearance of hair:
1. Pili annulati exhibits ringed or banded hairs.
2. Trichorrhexis nodosa exhibits conspicuous nodes due to immunodeficiency or small bowel disorder.
3. Parasites like head lice plant egg sacks on hairs.

N. Hair comparisons are performed using a comparison microscope. Two compound microscopes are connected together with an optical bridge which enables side-by-side comparisons of two specimens at a typical magnification of 100X to 250X.

O. The significance of hair evidence
1. Hair evidence cannot provide information such as age and gender without a nuclear DNA analysis on its follicular tag.
2. However, hair evidence can provide important investigative leads in many cases by determining the racial and somatic origin, as well as comparisons with known standards.
3. Hair can also be one of the most important evidence in cases involving identical twins (who cannot be distinguished by DNA analysis).
II. Fibers
   A. The origin of fibers
      1. Fibers are used in forensic science to create a link between a crime and a suspect.
      2. Fibers can originate from carpets, clothing, linens, furniture, insulation, rope, tape, etc.
      3. Fibers are sensitive evidence that can be easily lost or exchanged.
   B. Fiber types
      1. Natural
         a. Animal fibers
            1) Sheep (wool)
            2) Goat (mohair, cashmere)
            3) Camel (wool)
            4) Llama
            5) Alpaca (wool)
            6) Fur fibers from mink, rabbit, beaver, etc.
         b. Plant fibers
            1) Cotton
            2) Flax (linen)
            3) Ramie
            4) Sisal
            5) Jute
            6) Hemp
            7) Kapok
            8) Coir
      2. Synthetic
         a. Polyester
         b. Nylon
         c. Acrylics
         d. Rayon
         e. Acetates
   C. Weave patterns
      1. Plain
      2. Basket
      3. Satin
      4. Twill
      5. Leno
   D. Special fibers are commonly used in specific fields.
      1. Aramid fiber is a light, but strong, synthetic fiber.
         a. Heat-resistant aramid fiber is typically used for bullet-proof vests, military applications, and racing tires
         b. Fire-resistant aramid fiber is used for firemen or disaster response teams.
   E. Analytical methods used in forensic fiber analysis
      1. Microscopic comparison using comparison microscopes – They compare color, diameter, lines on the surface or the presence of a delustering agent, as well as cross-sectional shapes.
      2. Polarized light microscopy is used to determine birefringence (the difference between two refractive indices).
      3. Fourier Transform Infrared Spectrophotometry (FTIR) is used to
analyze the chemical composition and relative quantity for synthetic fibers.

4. Ultraviolet-visible range microspectrophotometry (UV-Vis MSP) is used to analyze subtle differences in fiber colors by comparing their absorption at different wavelengths.

Activities

1. Hair Scale Lab – students will examine and characterize the scale structure of animal and human hairs by using incident and transmitted light microscopy. A thin layer of clear nail polish is placed on a clean glass slide. A strand of hair from a known source is placed on the nail polish then removed after few minutes. Using transmitted light microscopy, the impression left on the dry nail polish surface is examined to characterize the hair scale structure. Use the Characteristics of Hair Scales Handout.

2. Hair Microscopy Lab – students will make a handbook containing the descriptions of hair characteristics to aid in the identification of different human and animal hairs. Up to ten different human and animal hairs should be examined by transmitted light microscopy to identify the species, racial, and somatic origin. A sample handbook is included.

3. Fiber Examination Lab – students will examine and characterize the gross appearance of different fibers collected from carpets and rugs by using incident and transmitted light microscopy. Tape lifts of carpets and rugs should be provided to the students to examine under microscope and to characterize their gross appearance, such as color, configuration, relative shaft diameter, pigments, and delustering agent.

4. Fiber Unit Review – students will research and answer the questions on the Fiber Unit Review. The students may work as individuals or as small groups.

Assessments

Trace Evidence: Hair Quiz and Key
Trace Evidence: Hair Exam and Key
Trace Evidence: Fiber Quiz and Key
Discussion Rubric
Individual Work Rubric

Note: All labs are guided; assess them based on the accuracy, details, and quality of the sketches, at the teacher’s discretion. No set rubric is provided.

Materials

Trace Evidence: Hair computer-based presentation
Trace Evidence: Fiber computer-based presentation
Characteristics of Hair Scales Handout
Hair Microscopy Handbook Sample
Fiber Unit Review
Glass slides
Glass cover slips
Clear nail polish
Tweezers
Permound (or other mounting media with a refractive index near 1.52)
Clear packing tape
Stereomicroscope with incident light source
Transmitted light microscope
Human hairs (various racial and somatic origins)
Animal hairs (various species)
Fiber samples

Resources

Do an Internet search for the following: Ted Bundy Rachel Bell

Accommodations for Learning Differences
For reinforcement, the student will draw a poster diagram of human and animal hair structure and characteristics. Use the Individual Work Rubric for assessment.

For enrichment, the student will examine the weave patterns of different textiles. Use the Individual Work Rubric for assessment.

State Education Standards
Texas Essential Knowledge and Skills for Career and Technical Education
§130.295. Forensic Science (One Credit).
(1) The student, for at least 40% of instructional time, conducts laboratory and field investigations using safe, environmentally appropriate, and ethical practices. These investigations must involve actively obtaining and analyzing data with physical equipment, but may also involve experimentation in a simulated environment as well as field observations that extend beyond the classroom. The student is expected to:
   (A) demonstrate safe practices during laboratory and field investigations; and
   (B) demonstrate an understanding of the use and conservation of resources and the proper disposal or recycling of materials.
(2) The student uses scientific methods and equipment during laboratory and field investigations. The student is expected to:
   (F) collect and organize qualitative and quantitative data and make measurements with accuracy and precision using tools such as calculators, spreadsheet software, data-collecting probes, computers, standard laboratory glassware, microscopes, various prepared slides, stereoscopes, metric rulers, electronic balances, gel electrophoresis apparatuses, micropipettors, hand lenses, Celsius thermometers, hot plates, lab notebooks or journals, timing devices, cameras, Petri dishes, lab incubators, meter sticks, and models, diagrams, or samples of biological specimens or structures;
(G) analyze, evaluate, make inferences, and predict trends from data; and

(H) communicate valid conclusions supported by the data through methods such as lab reports, labeled drawings, graphic organizers, journals, summaries, oral reports, and technology-based reports.

(3) The student uses critical thinking, scientific reasoning, and problem solving to make informed decisions within and outside the classroom. The student is expected to:

(A) in all fields of science, analyze, evaluate, and critique scientific explanations by using empirical evidence, logical reasoning, and experimental and observational testing, including examining all sides of scientific evidence of those scientific explanations, so as to encourage critical thinking by the student;

(D) evaluate the impact of scientific research on society and the environment;

(E) evaluate models according to their limitations in representing biological objects or events; and

(F) research and describe the history of science and contributions of scientists.

(6) The student analyzes the evidence collected from a crime scene using scientific methods. The student is expected to:

(G) identify the light sources used in forensic science such as ultraviolet light;

(H) explain the examination of trace evidence using instruments such as a spectrophotometer, stereoscope, electron microscope, and compound microscope;

(7) The student recognizes the methods to process and analyze trace evidence commonly found in a crime scene. The student is expected to:

(B) process trace evidence such as soil, grass, glass, blood, fibers, and hair collected in a simulated crime scene;

(C) compare the anatomy of the human hair to animal hair; and

(D) differentiate between natural and manufactured fibers.

College and Career Readiness Standards
Science
I. Nature of Science: Scientific Ways of Learning and Thinking
E. Effective communication of scientific information
   1. Use several modes of expression to describe or characterize natural patterns and phenomena. These modes of expression include narrative, numerical, graphical, pictorial, symbolic, and kinesthetic.
   2. Use essential vocabulary of the discipline being studied.
Characteristics of Hair Scales

Slide #: __________

Configuration (straight, wavy, or curly)?

Color: ____________________________

Relative shaft diameter (thin, moderate, or coarse)?

Scale pattern: ______________________

Animal or Human? __________________

Slide #: __________

Configuration (straight, wavy, or curly)?

Color: ____________________________

Relative shaft diameter (thin, moderate, or coarse)?

Scale pattern: ______________________

Animal or Human? __________________

Slide #: __________

Configuration (straight, wavy, or curly)?

Color: ____________________________

Relative shaft diameter (thin, moderate, or coarse)?

Scale pattern: ______________________

Animal or Human? __________________
Structure of Hair

3 Stages of Growth

1) ____________ Phase
   
2) ____________ Phase
   
3) ____________ Phase

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Human vs. Animal: 3 Main Differences

1) _____________________________________________________________________

_______________________________________________________________________

_______________________________________________________________________

_______________________________________________________________________

2) _____________________________________________________________________

_______________________________________________________________________

_______________________________________________________________________

_______________________________________________________________________

3) _____________________________________________________________________

_______________________________________________________________________

_______________________________________________________________________

_______________________________________________________________________
3 Scale Types

4 Types of Human Medulla

1) Absent

2) Fragmented

3) Discontinuous

4) Continuous
Racial Characteristics

1) Caucasian
   - Shaft diameter: ______________________
   - Pigment: ______________________
   - Cross-section shape: _____________
   - Cuticle thickness: _______________
   - Configuration: _________________

2) Mongoloid
   - Shaft diameter: ______________________
   - Pigment: ______________________
   - Cross-section shape: _____________
   - Cuticle thickness: _______________
   - Configuration: _________________

3) Negroid
   - Shaft diameter: ______________________
   - Pigment: ______________________
   - Cross-section shape: _____________
   - Cuticle thickness: _______________
   - Configuration: _________________
Somatic Origin

- Head Hairs

- Pubic Hairs

- Limb Hairs

Facial Hairs
- Beard/mustache

- Eyebrow/Eyelash

Other Body Hairs
- Chest Hairs

- Auxiliary or Underarm Hairs
Hair Characterization Exercises

Slide #

Human or animal?

Root: ________________________________

Configuration: ________________________________

Shaft Diameter: ________________________________

Color: ________________________________

Pigment Size & Density: ________________________________

Pigment Distribution: ________________________________

Medulla: ________________________________

Cuticle: ________________________________

Race (if human): ________________________________

Somatic origin (if human): ________________________________
Slide #

Human or animal?

Root: ____________________________________________

Configuration: ____________________________________________

Shaft Diameter: ____________________________________________

Color: ____________________________________________

Pigment Size & Density: ____________________________________________

Pigment Distribution: ____________________________________________

Medulla: ____________________________________________

Cuticle: ____________________________________________

Race (if human): ____________________________________________

Somatic origin (if human): ____________________________________________
Slide # _______ Human or animal?

Root: ____________________________________________

Configuration: __________________________________

Shaft Diameter: __________________________________

Color: __________________________________________

Pigment Size & Density: ____________________________

Pigment Distribution: ______________________________

Medulla: __________________________________________

Cuticle: __________________________________________

Race (if human): __________________________________

Somatic origin (if human): __________________________

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Slide #

Human or animal?

Root: ____________________________

Configuration: ___________________

Shaft Diameter: __________________

Color: __________________________

Pigment Size & Density: __________

Pigment Distribution: ______________

Medulla: _________________________

Cuticle: _________________________

Race (if human): __________________

Somatic origin (if human): __________
Slide #

Human  or  animal?

Root: ________________________________

Configuration: ________________________________

Shaft Diameter: ________________________________

Color: ________________________________

Pigment Size & Density: ________________________________

Pigment Distribution: ________________________________

Medulla: ________________________________

Cuticle: ________________________________

Race (if human): ________________________________

Somatic origin (if human): ________________________________
Slide # ___________  Human  or  animal?

Root: __________________________________________

Configuration: __________________________________

Shaft Diameter: __________________________________

Color: __________________________________________

Pigment Size & Density: __________________________

Pigment Distribution: ______________________________

Medulla: _________________________________________

Cuticle: _________________________________________

Race (if human): _________________________________

Somatic origin (if human): ________________________
Slide # ________ Human or animal?

Root: ________________________________

Configuration: _______________________

Shaft Diameter: _______________________

Color: _______________________________

Pigment Size & Density: ______________

Pigment Distribution: _________________

Medulla: ____________________________

Cuticle: ____________________________

Race (if human): ______________________

Somatic origin (if human): ___________
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Root: ________________________________

Configuration: ________________________________

Shaft Diameter: ________________________________

Color: ________________________________

Pigment Size & Density: ________________________________

Pigment Distribution: ________________________________

Medulla: ________________________________

Cuticle: ________________________________

Race (if human): ________________________________

Somatic origin (if human): ________________________________
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Trace Evidence: Hair Unit Exam

**Part I: True or False** (5 points each)

1) _____ Only human hairs have the imbricate scales.

2) _____ The gender of a questioned hair can be determined based on microscopic hair examination.

3) _____ Ovoid bodies are only seen in animal hairs.

4) _____ Different dogs of the same breed can be distinguished if the roots are present.

**Part II: Multiple Choices** (5 points each)

5) _____ What is the protein that makes up the hair shaft?
   a. Melanin
   b. Pheomelanin
   c. Keratin
   d. Medulla

6) _____ Which one of the following components of hair can be used in nuclear DNA analysis for personal identification?
   a. Medulla
   b. Scales
   c. Cortex
   d. Follicular tag

7) _____ Which one of the following growth stages typically has the largest amount of pigments?
   a. Catagen
   b. Anagen
   c. Telogen
   d. Postmortem

8) _____ Which one of the following growth stages typically has the most amount of cortical fusi?
   a. Catagen
   b. Anagen
   c. Telogen
   d. Postmortem

9) _____ Flat cross-sections are typically seen in _____________ hairs.
   a. Mongoloid
   b. Negroid
   c. Caucasian
   d. Animal

10) _____ Forensic human hair comparisons are only performed on
a. Head and pubic hairs  
b. Head and facial hairs  
c. Facial and pubic hairs  
d. Facial, head, and pubic hairs

**Part III: Short Answers**

11) List and describe the three main differences between human and animal hairs. (6 pts.)

12) Describe the differences in pigments between the three racial groups. Be sure to include the differences in pigment size, density, and any special characteristics. (11 pts.)

13) Describe how one can distinguish the difference between head and pubic hairs. (4 pts.)
14) Explain why hair evidence can be used to distinguish between a set of identical twins when nuclear DNA analysis cannot. (5 pts.)

15) Fill in the blanks. (12 pts.)

16) Identify the origin for each of the following pictures using the list below. (12 pts.)

- Caucasian head hair
- Rabbit fur hair
- Bat hair
- Deer hair
- Caucasian pubic hair
- Dog hair
a.

b.

c.

d.
Trace Evidence: Hair Unit Exam Key

Part I: True or False (5 pts. each)

1) F
2) F
3) F
4) F

Part II: Multiple Choices (5 pts. each)

5) C
6) D
7) B
8) C
9) B
10) A

Part III: Short Answers

11) - Pigments
    Human hair pigments are consistent throughout the hair.
    Animal hair pigments exhibit radical changes.

    - Scales
      Human hairs have imbricate scales.
      Animal hairs can have imbricate, coronal, or spinous scales.

    - Medulla
      A human hair medulla has a width of less than 1/3 of the shaft diameter and is amorphous.
      Animal hair medullae are thick and have distinct patterns. (6 pts.)

12) - Caucasian hair pigments tend to be fine and light in density.
    - Negroid hair pigments tend to have moderate size, heavy density, and aggregated clumping.
    - Mongoloid hair pigments tend to be large, heavily dense, and streaky. (11 pts.)

13) - Head hairs are typically longer than pubic hairs, and are often seen with artificial treatment.
    - Pubic hairs are typically coarse and exhibit “buckling.” (4 pts.)

14) Because hair characteristics can be influenced by not only the genetics, but also environmental effects such as one’s diet, weather, or artificial treatment. (5 pts.)

15) Fill in the blanks. (12 pts.)
16) a. Bat hair  
b. Rabbit fur hair  
c. Caucasian pubic hair  
d. Deer hair (12 pts.)
Trace Evidence: Hair Quiz

Multiple Choices

1) Human hairs have scales.
   a) coronal
   b) imbricate
   c) spinous
   d) amorphous

2) Hairs can be used for the purpose of identification:
   a) only if a follicular tag is present.
   b) only if the proximal end is present.
   c) only if the distal end is present.
   d) only if ovoid bodies are present.

3) Which one of the following is the pigment found in redheads?
   a) Keratin
   b) Melanin
   c) Pheomelanin
   d) Cortex

4) The central cells that are not always visible or present are called the ______.
   a) Cortex
   b) Medullae
   c) Cuticle
   d) Scales

5) Bailey sat on a couch to watch a football game. Later on that day, Abby sat in the same spot and Bailey's head hair was found on her sweater. This is an example of
   a) Primary transfer
   b) Direct transfer
   c) Secondary transfer
   d) Cross-transfer

Short Answers

6) Name and define the 3 stages of hair growth based on the root shape.
7) Fill in the blanks with names of the hair characteristics shown.

- cuticle
- distal
- proximal
- pigment granule
Trace Evidence: Hair Quiz Key

1) B
2) A
3) C
4) B
5) C
6) - Anagen – active growth phase (abundance of pigments, ribbon-like root). Often found with follicular tag.
   - Catagen – the intermediate growth phase (elongated root shape).
   - Telogen – resting phase (bulb-like root shape with fewer pigments). Often found with abundance of cortical fusi.

7)
Trace Evidence: Fiber Unit Review

1) What are the two major categories of fibers?

2) What are natural fibers derived from?

3) What is the most common natural animal fiber?

4) What is the most common natural plant fiber?

5) What is Hemp? What is it typically used for?

6) What is the most common synthetic fiber? What are its characteristics?

7) Describe the following synthetic fibers:
   a. Nylon
   b. Acrylics
   c. Acetates
8) What is the main difference between the microscopic appearances of natural and synthetic fibers?

9) Compare heat-resistant aramid fiber and flame-resistant aramid fiber.

10) Name the four common weave patterns used in the textile industry.

11) What are some microscopic characteristics examined and used to compare fibers?

12) Define the following:
   a. Polarized light microscopy
   b. Birefringence
   c. FTIR
   d. UV-Visible Microspectrophotometry

13) Name the three people who have been convicted of murder(s) based on fiber evidence.
Trace Evidence: Fiber Unit Review Key

1) Natural and synthetic
2) Animals and plants
3) Sheep’s wool
4) Cotton
5) Hemp is a common name for cannabis for industrial use. It is typically used for rope or sack.
6) Polyester. Wrinkle-resistant and often spun together with cotton or other natural fibers for a more “natural” look.
7) **Nylon** – elastic, and strong when produced as fibers. When stretched it becomes shiny and silk-like in appearance. It is often used in hosiery and was first created by DuPont in 1935.
   - **Acrylics** – wool-like, soft, and warm, it is resistant to moths, sunlight, oil, chemicals, and quick-drying.
   - **Acetates** – cellulose-based, wrinkle-resistant fibers. Made from cellulose of softwood trees dissolved in acetic acid solution.
8) Natural fibers appear to be irregular (with twists and curls) in their shaft diameter, while synthetic fibers appear more regular and consistent in their diameter. Natural fibers made from animal hair will have scales.
9) Heat resistant aramid fiber is a light, but strong, synthetic fiber that is typically used for bulletproof vests, military applications, and racing tires. Fire-resistant aramid fiber and used by firemen or disaster response teams.
10) Plain, Basket, Satin and Twill
11) Color, Diameter, Lines/markings on the surface, Presence or absence of delustering agents, Cross-sectional shapes
12) **Polarized light microscopy** – a light microscope with two polarizing filters that is used to determine birefringence
   - Birefringence – the difference between two refractive indices
   - **FTIR** – Fourier Transform Infrared Spectrophotometry is an analytical instrument used to analyze the chemical composition and relative quantity of synthetic fibers
   - **UV-Visible Microspectrophotometry** – an analytical instrument used to determine the absorption or transmittance of samples at different wavelengths within the ultraviolet and visible range
13) Ted Bundy, Wayne Williams and John Joubert
Trace Evidence: Fiber Quiz

Matching
1) _____Cotton
2) _____Acrylic
3) _____Hemp
4) _____Acetates
5) _____Polyester

A) Cellulose-based synthetic fiber
B) The most common natural fiber
C) Wrinkle-resistant synthetic fiber
D) Industrially used cannabis fiber
E) Wool-like synthetic fiber

Multiple Choice
6) _____Which one of the following analytical methods is used to determine the chemical composition of a fiber?
   a. Polarized light microscopy
   b. Fourier Transform Infrared Spectrophotometry
   c. UV-Visible Microspectrophotometry
   d. Stereomicroscopy

7) _____What is birefringence?
   a. The difference between two refractive indices
   b. The angle between two fibers
   c. The angle between two refraction
   d. Yarn with two layers of fibers

8) _____All of the following characteristics are examined in fiber comparisons EXCEPT
   a. Color
   b. Cross-section
   c. Diameter
   d. Follicular tag
Short Answer

9) Name the two types of aramid fiber and describe the typical end use of each.

10) What is the main difference between natural and synthetic fibers in their microscopic appearance?

11) Name the four most common textile weave patterns.

12) Name two people who have been convicted of murder(s) based on fiber evidence.
Trace Evidence: Fiber Quiz Key

1) B
2) E
3) D
4) A
5) C
6) B
7) A
8) D
9) Heat-resistant aramid fiber – is typically used for bulletproof vests, military applications, racing tires, etc.
   Fire-resistant aramid fiber – typically used for firemen’s uniforms, disaster response, etc.
10) Natural fibers – appear irregular and sometimes twisty, with varying diameters.
    Synthetic fibers – appear uniform with regular/consistent diameters and characteristic cross-sections.
11) Plain, Basket, Satin, Twill
12) Any of the cases studied. Examples include: Ted Bundy, Wayne Williams, and John Joubert.
## Discussion Rubric

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<td>Encourages others to join the conversation</td>
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<td>Keeps the discussion progressing to achieve goals</td>
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<td>Shares thoughts actively while offering helpful recommendations to others</td>
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<td>Gives credit to others for their ideas</td>
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<td>Respects the opinions of others</td>
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<td>Involves others by asking questions or requesting input</td>
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<td>Expresses thoughts and ideas clearly and effectively</td>
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**Total Points (32 pts.)**

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<td>Student documented information in his or her own words and can accurately answer questions related to the information retrieved</td>
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<td>Student used a variety of methods and sources to gather information. Student took notes while gathering information</td>
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