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| **TEXAS CTE LESSON PLAN**[www.txcte.org](http://www.txcte.org) |
| **Lesson Identification and TEKS Addressed** |
| **Career Cluster** | Law, Public Safety, Corrections, & Security |
| **Course Name** | Forensic Science |
| **Lesson/Unit Title** | Trace Evidence: Hair and Fiber |
| **TEKS Student Expectations** | **130.339. (c) Knowledge and Skills**(2) The student, for at least 40 of instructional time, conducts laboratory and/or field investigations using safe, environmentally appropriate, and ethical practices. (A) The student is expected to demonstrate safe practices during laboratory and field investigations(B) The student is expected to demonstrate an understanding of the use and conservation of resources and the proper disposal or recycling of materials(3) The student uses scientific methods and equipment during laboratory and field investigations. (F) The student is expected to 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, dissection equipment, meter sticks, and models, diagrams, or samples of biological specimens or structures(G) The student is expected to analyze, evaluate, make inferences, and predict trends from data(H) The student is expected to communicate valid conclusions supported by the data through methods such as investigative reports, lab reports, labeled drawings, graphic organizers, journals, summaries, oral reports, and technology-based reports(4) The student uses critical thinking, scientific reasoning, and problem solving to make informed decisions within and outside the classroom. (A) The student is expected to 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, to encourage critical thinking(D) The student is expected to evaluate the impact of scientific research on criminal investigation, society, and the environment(E) The student is expected to evaluate models according to their limitations in representing biological objects or events(F) The student is expected to research and describe the history of science and contributions of scientists within the criminal justice system(7) The student recognizes the methods to process and analyze trace evidence commonly found in a crime scene. (A) The student is expected to demonstrate how to process trace evidence such as glass, paint, fibers, hair, soil, grass, and blood collected in a simulated crime scene(F) The student is expected to compare and contrast the microscopic characteristics of human hair and animal hair, including medulla, pigment distribution, and scales(G) The student is expected to describe and illustrate the different microscopic characteristics used to determine the racial and somatic origin of a human hair sample(H) The student is expected to differentiate between natural and synthetic fibers |
| **Basic Direct Teach Lesson**(Includes Special Education Modifications/Accommodations and one English Language Proficiency Standards (ELPS) Strategy) |
| **Instructional Objectives** | The students will be able to:* Identify the racial and somatic origin of unknown hairs based on their characteristics.
* Distinguish between human and animal hairs.
* Distinguish between natural and synthetic fibers.
* Examine the subtle differences between questioned and known samples of hairs and fibers.
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| **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. |
| **Duration of Lesson** | 3 Class Periods |
| **Word Wall/Key Vocabulary***(ELPS c1a,c,f; c2b; c3a,b,d; c4c; c5b) PDAS II(5)* |  |
| **Materials/Specialized Equipment Needed** | * Characteristics of Hair Scales Handout
* Hair Microscopy Handbook Sample
* Fiber Unit Review
* Glass slides
* Glass cover slips
* Clear nail polish
* Tweezers
* Permount (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
* Trace Evidence: Hair Quiz and Key
* Trace Evidence: Hair Exam and Key
* Trace Evidence: Fiber Quiz and Key
* Discussion Rubric
* Individual Work Rubric
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| **Anticipatory Set**(May include pre-assessment for prior knowledge) | 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. |
| **Direct Instruction \*** | 1. 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.
	1. 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.
	2. 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).
	3. 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)
2. 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.
3. 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.
4. 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.
5. 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).
6. Variations in the distal end (tip) include
	1. Scissor-cut distal
	2. Abraded
	3. Razor-cut
	4. Rounded
	5. Broken
	6. Burnt
7. Three main differences between Human and Animal hairs
	1. Pigments
		1. Human hair pigments remain consistent in their color and pigmentation throughout the length of the hair shaft.
		2. Animal hair pigments often exhibit rapid and radical color changes.
	2. Medulla
		1. Human hair medullae are thin and take up no more than 1/3 of the hair shaft diameter. They appear amorphous.
		2. 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
		1. Human hairs have overlapping imbricate scales with narrow margins.
		2. Some animal hairs may have imbricate scales, coronal (crown-shaped) scales, or spinous (petal-shaped) scales.
8. 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.
9. 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.
10. 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.
11. 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.
12. 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.
13. 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).
14. Fibers
	1. 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.
	2. Fiber types
		1. Natural
			1. 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.
			2. Plant fibers
				1. Cotton
				2. Flax (linen)
				3. Ramie
				4. Sisal
				5. Jute
				6. Hemp
				7. Kapok
				8. Coir
		2. Synthetic
			1. Polyester
			2. Nylon
			3. Acrylics
			4. Rayon
			5. Acetates
	3. Weave patterns
		1. Plain
		2. Basket
		3. Satin
		4. Twill
		5. Leno
	4. Special fibers are commonly used in specific fields.
		1. Aramid fiber is a light, but strong, synthetic fiber.
			1. Heat-resistant aramid fiber is typically used for bullet-proof vests, military applications, and racing tires
			2. Fire-resistant aramid fiber is used for firemen or disaster response teams.
	5. 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.

*Individualized Education Plan (IEP) for all special education students must be followed. Examples of accommodations may include, but are not limited to:*NONE |
| **Guided Practice \*** | 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.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.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.*Individualized Education Plan (IEP) for all special education students must be followed. Examples of accommodations may include, but are not limited to:*NONE |
| **Independent Practice/Laboratory Experience/Differentiated Activities \*** | 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.*Individualized Education Plan (IEP) for all special education students must be followed. Examples of accommodations may include, but are not limited to:*NONE |
| **Lesson Closure** |  |
| **Summative/End of Lesson Assessment \***  | * Trace Evidence: Hair Quiz
* Trace Evidence: Hair Exam
* Trace Evidence: Fiber Quiz

*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.**Individualized Education Plan (IEP) for all special education students must be followed. Examples of accommodations may include, but are not limited to:*NONE |
| **References/Resources/****Teacher Preparation** | * Saferstein, Richard. *Forensic Science: An Introduction*. New Jersey: Pearson Prentice Hall, 2008.
* Saferstein, Richard. *Criminalistics: An Introduction to Forensic Science*. 8th ed. Upper Saddle River, NJ: Pearson Prentice Hall, 2004.
* Saferstein, Richard. *Forensic Science Handbook*. Englewood Cliffs, NJ: Prentice-Hall, 1982.
* Bertino, Anthony J. *Forensic Science: Fundamentals and Investigations*.
* Mason, OH: South-Western Cengage Learning, 2009.
* Do an Internet search for the following: Ted Bundy Rachel Bell.
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| **Additional Required Components** |
| **English Language Proficiency Standards (ELPS) Strategies** |  |
| **College and Career Readiness Connection[[1]](#footnote-1)** | **Science**I. Nature of Science: Scientific Ways of Learning and Thinking E. Effective communication of scientific information1. 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.
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| **Recommended Strategies** |
| **Reading Strategies** |  |
| **Quotes** |  |
| **Multimedia/Visual Strategy****Presentation Slides + One Additional Technology Connection** |  |
| **Graphic Organizers/Handout** |  |
| **Writing Strategies****Journal Entries + 1 Additional Writing Strategy** |  |
| **Communication****90 Second Speech Topics** |  |
| **Other Essential Lesson Components** |
| **Enrichment Activity**(e.g., homework assignment) | 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. |
| **Family/Community Connection** |  |
| **CTSO connection(s)** | SkillsUSA |
| **Service Learning Projects** |  |
| **Lesson Notes** |  |

1. Visit the Texas College and Career Readiness Standards at <http://www.thecb.state.tx.us/collegereadiness/CRS.pdf>, Texas Higher Education Coordinating Board (THECB), 2009. [↑](#footnote-ref-1)