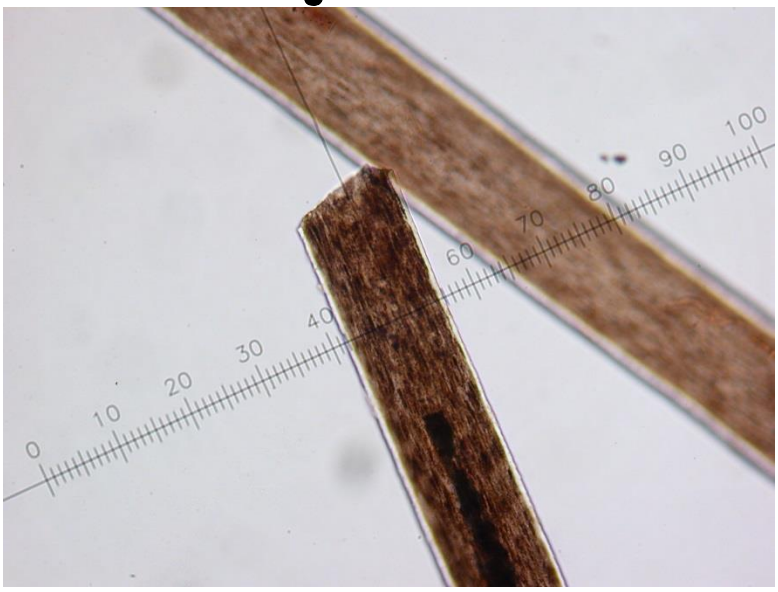
Washington State Patrol



Crime Laboratory Division

Materials Analysis
Hair Analysis Training Manual

January 2023

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1 INTRODUCTION

1.1 PURPOSE AND SCOPE

This manual contains an outline for training and/or assessing a forensic scientist in the area of Hair Analysis. The various study segments should be covered in the order presented.

This manual endeavors to promote and maintain consistency and quality among forensic scientists performing Hair analyses across the Crime Laboratory Division. Certain inherent aspects of Hair Analysis prohibit the establishment of a rigid set of standard procedures to cover every case. Sufficient latitude should be given to allow for independent thought and individual freedom in selecting alternative courses of action. Upon completion of this training program, the trainee will be thoroughly familiar with the options available to perform an examination of most types of evidence that may be received.

1.2 EXPECTATIONS

The trainee is expected to have successfully completed the following chapters from the Materials Analysis Instrumentation and Techniques Training Manual: Evidence Recovery, Imaging and Visualization, Microscopy (Basic), Screening and Evaluation of Trace Evidence.

Trainees who have prior related training and experience can progress through the training program at an accelerated pace or skip certain study segments. The required documentation of such related training and/or experience shall be left to the supervisor in coordination with the technical lead(s) or their designee.

The instructor shall be experienced in the area of Hair Analysis. The instructor's casework and courtroom experiences, both prior and present, provide a unique aspect to the trainee's learning process that is impossible to duplicate in this training program. The instructor shall share such experiences with the trainee. The instructor shall also discuss with the trainee the training and reference materials (if any) available on the FLSB Portal. Although the trainee's primary interaction shall be with the assigned instructor, this program promotes and encourages discussions with other experienced examiners. When possible, the trainee should also take outside courses related to Hair Analysis.

The trainee shall maintain a notebook or multiple notebooks throughout the duration of this training program and shall record notes and observations for each study segment. The trainee notebook should be maintained in a neat and current fashion and should be present during conversations with the trainer. Upon completion of training, the trainee shall maintain the training notebook for the duration of their career. The form of the notebook(s) can be written, electronic, or a combination thereof.

The trainee is continuously evaluated throughout the training for comprehension and competency in theoretical knowledge, basic practical skills, and critical thinking skills. Training is progressive and continuously builds on and reinforces prior learning. Deficiencies on any of the training steps during the course of the training shall be rectified. It is important that these deficiencies be openly and promptly discussed among the trainee, trainer, technical lead, and/or supervisor, as appropriate. If necessary, training steps and testing can be repeated to satisfactorily complete this training program.

In order to successfully complete this training program the trainee shall, after completion of all topic areas, successfully complete a closed book written exam passed with 80%, a competency exam passed with a 100%, and an oral testimony exam with a pass/fail. The completion of these steps shall be documented on a training checklist located at the end of this manual. The checklist may be filled out electronically and may refer to email records rather than requiring handwritten initials. The competency exam shall take the form of a mock case, which shall include a draft report. The oral testimony exam can either be a full moot court or an oral examination of testimony type questions between the trainer and the trainee. Supervised casework is optional and dependent on the trainee's repertoire of subdisciplines as well as performance on mock casework.

The trainer is responsible for writing an interoffice communication (IOC) to the trainee's supervisor when the trainee has successfully completed the Hair Analysis Training Manual. Training records, including training IOCs and authorizations, will be maintained in accordance with QOM requirements. Individual scientists are strongly encouraged to maintain copies of their own training records and their training notebook(s).

1.3 ORGANIZATION OF THE TRAINING MANUAL

This training manual consists of four segments, each covering different aspects of Hair Analysis. The study segments are organized in a specific manner to build on each other. Understanding what a hair is comes first with the study segment on physiology and anatomy. This segment includes the parts of a hair and the types of hairs. The next segment covers how to identify hairs that should go to DNA. The third segment covers investigative exams. The final segment puts everything learned into a casework perspective. The final segment covers evidentiary significance of hair exams, a review of previous cases, performing a series of mock cases, and learning court preparation.

Each study segment is comprised of five sections:

Objectives – Summarize the purpose of each study segment.

Topic Areas – Designates topics to be included in the study segment.

Readings – Lists the reference materials that should be read to complete the study segment.

Study Questions – Lists questions that assist the trainee in comprehension of the readings, promotes active discussion between the trainer and trainee, and documents understanding of the topic areas. Written answers to these questions will be maintained in the training notebook as documentation of training.

Practical Exercises – Hands on activities that are designed to provide the trainee first-hand experience with the main concepts of each study segment. Data or written explanation for each exercise must be maintained in the training notebooks.

1.4 SAFETY

Good chemical safety practices shall be employed.

2 BASIC PHYSIOLOGY AND ANATOMY

2.1 OBJECTIVES

- To become familiar with hair physiology and the anatomical features used in hair analysis.
- To learn the various types of human and animal hairs

2.2 TOPIC AREAS

1. Hair Anatomy
   a. Along Length
      i. Root
      ii. Proximal End
      iii. Shaft
      iv. Distal End
      v. Tip
   b. Cross Section of Shaft
      i. Medulla
      ii. Cortex
      iii. Cuticle
2. Microscopic Features
   a. Cortical Fusi
   b. Ovoid Bodies
   c. Pigment Granules
3. Types of Human Hairs
   a. Lanugo
   b. Vellus
   c. Terminal
      i. Primary
      ii. Secondary (Puberty)
4. Types of Animal Hairs
   a. Whiskers
   b. Guard
   c. Wool/Fur

2.3 READINGS

1. ASTM E3316-22 Standard Guide for Forensic Examination of Hair by Microscopy [read section 3. Terminology].
2. Bisbing RE **(2020)** “The forensic identification and association of human hair”. In Richard Saferstein (Ed.) *Forensic Science Handbook, Volume I, Third Edition* (pp 151-200) CRC Press, Taylor & Francis Group. [Note: read The Pilary Apparatus (p 154) and Hair Structure (pp154-160).]
3. Harding H and Rogers G **(1999)** “Physiology and growth of human hair”. In James Robertson (Ed.) *Forensic Examination of Hair* (pp 1-77) London, UK: Taylor and Francis. [Note: read 1.4 The Hair (pp 15-25), and 1.7.1 Hair Types (pp 46-47), and 1.10 Hair Colour and Pigmentation (pp 56-59).]

4. Hicks JW **(1977)** *Microscopy of Hairs A Practical Guide and Manual*, FBI Laboratory Technical Supplement, FBI, Washington D.C. [Note: read Basic Structure of Hair (pp 1-5).]

2.4 STUDY QUESTIONS

1. What is a hair?
2. What are the two predominant classes of chemicals found in hair?
3. What are the proximal and distal ends of a hair?
4. How is the hair attached to skin?
5. What is the difference between a hair and a hair fragment?
6. What are the three layers of a hair?
7. Are all 3 layers always present?
8. What is the anatomy of the cuticle and how is it related to the proximal and distal ends?
9. Describe the color, size range, and location within the hair of the two different types of pigment grains. Can they both be present in the same hair?
10. What are cortical fusi and where are they found?
11. What are ovoid bodies and where are they found?
12. What is the medullary ratio (aka the medullary index)?
13. Describe the different types of human hairs.
14. Describe the 3 different types (major categories) of animal hairs.
15. What type(s) of hairs may be used to identify an animal species?

2.5 PRACTICAL EXERCISES

1. Obtain a set of images from your trainer.
    a. Label all the parts marked with arrows.
    b. Determine the approximate medullary ratio where possible.

3 SUITABILITY FOR DNA EXAMS

3.1 OBJECTIVES

- To learn to distinguish hairs and fibers.
- To learn to identify if a hair is an animal hair or a human hair.
- To learn the growth stages of a human hair.
- To learn to identify the features of human hairs that may be used to determine suitability to attempt different types of DNA analyses.

3.2 TOPIC AREAS

1. Apparent Hair/Fiber Features
    a. Length
    b. Width
    c. Surface appearance
    d. Cross section
    e. General form
    f. Pigmentation
    g. Delustrant (also spelled delusterant)
    h. Layers (e.g. medulla, cuticle, cortex)
2. Human Hair Growth Cycle
    a. Growth Stages – Follicle Appearance
        i. Anagen
        ii. Catagen
        iii. Telogen
        iv. (Exogen)
    b. Categorization for DNA
        i. Active or
        ii. Inactive
    c. Microscopic Characteristics
        i. Root shape
        ii. Pigmentation changes near root
        iii. Frequency of cortical fusi near root
3. Root Tissue
    a. Germinal nipple
    b. Plug
    c. Casting
    d. Sheath
    e. Follicular tag
4. Three Key Questions
    a. Is the particle a hair, hair fragment, fiber, or something else?
    b. If the particle is a hair, is it human or animal?
    c. If the particle is a human hair, what features are present/absent that may be used to determine the appropriate type of DNA analysis?

3.3 READINGS

1. Current Hair Analysis chapter from the Materials Analysis Technical Procedures Manual.
2. "Hair Guidance for DNA Analysts" document found on the Portal under CLD/DNA/Shared Documents.
3. ASTM E3316-22 Standard Guide for Forensic Examination of Hair by Microscopy [read section 3. Terminology].
4. Bisbing RE **(2020)** "The forensic identification and association of human hair". In Richard Saferstein (Ed.) *Forensic Science Handbook, Volume I, Third Edition* (pp 151-200) CRC Press, Taylor & Francis Group. [Note: read Growth and Replacement of Hair (pp 160-164), Species Origin (p 165), and Microscopy and DNA Analysis (pp 177-180).]
5. Boonen T, Vits K, Hoste B, and Hubrecht F **(2008)** "The visualization and quantification of cell nuclei in telogen hair roots by fluorescence microscopy, as a pre-DNA analysis assessment" in *Forensic Science International: Genetics Supplement Series* 1(1): 16-18.
6. Dizinno, JA, Wilson MR, and Budowle B **(1999)** "Typing of DNA derived from hairs". In James Robertson (Ed.) *Forensic Examination of Hair* (pp 155-173) London, UK: Taylor and Francis. [Note: read 3.2 DNA – a Brief Summary (p 156) and 3.3 Mitochondrial DNA (pp 156-159).]
7. Edson J, Brooks EM, McLaren C, Robertson J, McNevin D, Cooper A, and Austin JJ **(2013)** "A quantitative assessment of a reliable screening technique for the STR analysis of telogen hair roots" in *Forensic Science International: Genetics* 7: 180-188.
8. Geyfman M, Plikus MV, Treffeisen E, Andersen B, and Paus R **(2015)** "Resting no more: re-defining telogen, the maintenance stage of the hair growth cycle" in *Biological Reviews - Cambridge Philosophical Soci*ety 90(4): 1179-1196.
9. Harding H and Rogers G **(1999)** "Physiology and growth of human hair". In James Robertson (Ed.) *Forensic Examination of Hair* (pp 1-77) London, UK: Taylor and Francis. [Note: read 1.6 The Hair Cycle (pp 40-46), and 1.8 Hair Growth, Distribution and Patterns (pp 49-52), and 1.9 Hair Growth Problems (pp 52-56).]
10. Hicks JW **(1977)** *Microscopy of Hairs A Practical Guide and Manual*, FBI Laboratory Technical Supplement, FBI, Washington D.C. [Note: read only Animal Hairs (pp 28-40).]
11. King LA, Wigmore R, and Twibell JM **(1982)** "The morphology and occurrence of human hair sheath cells" in *Journal of the Forensic Science Society* 22(3): 267-269.
12. Lawas M, Otterstatter LM, Friedman JD, and Donfack J **(2022)** "Survey of mounting media used for hair and fiber microscopy" in the *Journal of the American Society of Trace Evidence Examiners* 12(1) 3-21.
13. Linch CA and Prahlow JA **(2001)** "Postmortem microscopic changes observed at the human head hair proximal end" in *Journal of Forensic Sciences* 46(1): 15-20.
14. Linch CA, Smith SL, and Prahlow JA **(1998)** "Evaluation of the human hair root for DNA typing subsequent to microscopic comparison" in *Journal of Forensic* Sciences 43(2): 305-314.
15. McGinnis M and Thornton J **(1986)** "Narrow medullae in animal hair" in *Crime Laboratory Digest* 13(2) 51-53.
16. Moore TD, Spence LE, and Dugnolle CE **(1974)** "Glossary". In William G. Hepworth (Ed.) *Identification of the Dorsal Guard Hair of Some Mammals of Wyoming* (pp 3-17) Cheyenne, Wyoming: Wyoming Game and Fish Department.
17. Pettenati M, Rao N, Linch C, and Prahlow J **(1999)** "Commentary on Linch CA, Smith SL, Prahlow JA. Evaluation of the Human Hair Root for DNA Typing Subsequent to Microscopic Comparison. J Forensic Sci. 1998; 43(2):305–14," in *Journal of Forensic Sciences* 44(6): 1329-1330,

18. Petraco N, Fraas C, Callery FX, and DeForest PR **(1988)** "The morphology and evidential significance of human hair roots". *Journal of Forensic Sciences* 33(1) 68-76.

19. Petraco N and Kubic T **(2004)** *Color Atlas and Manual of Microscopy for Criminalists, Chemists, and Conservators* New York: CRC Press. [Note: read only Animal Hair Identification (pp 69-76) and Appendix B: Animal Hair Atlas (pp 239-255)

20. Robbins CR **(1988)** "Morphological and macromolecular structure". In *Chemical and Physical Behavior of Human Hair, Second Edition* (pp 1-38) New York: Springer-Verlag. [Note: read Hair Growth (pp 4-8).]

21. Robertson J **(1999)** "Forensic and microscopic examination of human hair". In James Robertson (Ed.) *Forensic Examination of Hair* (pp 79-154) London, UK: Taylor and Francis. [Note: read 2.3 Non-human Hair (pp 80-84).]

22. Roe GM, Cook R, and North C **(1991)** "An evaluation of mountants for use in forensic hair examination" in *Journal of the Forensic Science Society* 31: 59-65.

23. Siegel JA and Mirakovits K **(2010)** *Forensic Science the Basics*, CRC Press: Taylor and Francis. [Note: read subsection on Textile Fibers (pp 410-416).]

24. Tridico SR, Houck MM, Kirkbride KP, Smith ME, and Yates BC **(2014)** "Morphological identification of animal hairs: Myths and misconceptions, possibilities and pitfalls" in *Forensic Science International* 238: 101- 107.

3.4 STUDY QUESTIONS

1. What is delustrant?
2. What is a "fish-eye" in a fiber?
3. What features distinguish fibers from hairs/hair fragments?
4. What is banding?
5. What features distinguish animal and human hairs?
6. What mounting media may be used with hair exams?
7. Why is mounting in Permount or water discouraged?
8. Describe the growth cycle of a human hair. List the changes that occur between the different stages.
9. What is the exogen stage?
10. Can the exogen stage be differentiated from the telogen stage by microscopic analysis? Do they differ in terms of their potential for nuclear STR DNA analysis?
11. What is a germinal nipple?
12. What is the typical growth stage of a hair that has a tissue sheath?
13. What features may be used to determine the type of DNA analysis to be used? (Include types of DNA for each feature.)
14. Does the quantity of tissue microscopically visible on a root correlate with DNA yield or generation of a suitable STR profile?
15. Discuss with your trainer the "Hair Guidance for DNA Analysts" document found on the Portal under CLD/DNA/Shared Documents.

3.5 PRACTICAL EXERCISES

1. Observe a demonstration of a hair examination of known samples (loose and adhered to sticky notes) by your trainer. Samples shall include human hairs, dog hairs, cat hairs, man-made clothing fibers, man-made carpet fibers, cotton fibers, and wool fibers.
    a. Visual Exam (unmounted). Note the following features: color, end morphology viewed from the side and end on, general form, length, and relative thickness.
    b. Reflected Light Stereomicroscope Exam (unmounted). Note the following features: color (e.g. dye lines, banding, opaque), end morphology viewed from the side (e.g. root end, tip, broken), end morphology viewed end on (e.g. unusual optical cross section), general form, relative thickness, and surface features (e.g. lobes, scales, smoothness).
    c. Light Microscope Exam (mounted in xylene substitute). Note the following features: color (color changes), ends (root end, tip), relative thickness, internal features (type of medulla, presence of delustrant, medullary ratio).
2. Observe a set of typical known samples mounted on sticky notes provided by the trainer. Use visual and reflected light stereomicroscope exams. Note relevant features that indicate what type of material you are examining. Review the observed features with the trainer and together temporarily mount any samples that had unclear features and examine with a light microscope. Be sure to add drops of xylene substitute to the sticky note adhesive to loosen it before removing the particle.
3. Observe a demonstration of the oblique light test by your trainer. A flashlight, goose neck lamp, or other light source at a low angle should illuminate a dark, delustered fiber and a dark, heavily pigmented human hair. All other light sources should be turned off. Be sure to observe the demonstration on unmounted samples with a stereomicroscope and xylene substitute mounted samples on a light microscope.
4. Observe a demonstration by your trainer of slide preparations with different semi-permanent mounting media and prepare a set of slides from human and animal hairs for each mounting medium. Allow to dry overnight. The next day, prepare additional fresh mounts in xylene substitute, water, and “dry mounted” (no mounting medium). Observe and compare observations with stereo and PLM. Note the difference in contrast with the surface features versus the internal features for the different mounting media.
5. Observe a set of hair fragments and hair “mimic” samples (e.g. natural wig fibers, synthetic wig fibers, and doll hair fibers). Use a visual exam, stereomicroscope exam, the oblique light test with a stereomicroscope, and light microscope exam.
6. Observe a set of known human hair samples with different amounts of tissue and different growth stages. Note the amount of pigmentation in the shaft versus near the root, the amount of cortical fusi near the root, the shape and length of the root, and the relative thickness of the root compared to the shaft. Note if any tissue is present, and if so, what general appearance (e.g. germinal nipple, small amount, plug, large amount, sheath, casting).
7. Observe a set of unknown samples on sticky notes provided by your trainer. Answer the Three Key Questions (listed in the Topics) for each sample. Use visual and reflected light stereomicroscope exams. Note relevant features that indicate that type of material you are examining. If necessary, use the oblique light test with the stereomicroscope and/or remove and mount the samples in xylene substitute and observe with a light microscope.
8. Practice removing hairs and possible hairs from the samples listed below. Try to target possible hairs that do not have clear cut features. Examine the apparent hairs, note the relevant features, and answer the Three Key Questions (listed in Topics). Save the apparent hairs for your trainer to examine and compare with your notes.
    a. Dryer lint (from residential or commercial machines)
    b. Vacuum sweepings (from residential bag or forensic filters)

c. Dust bunnies (loose or picked up by sticky notes).

9. Observe a set of tape lifts from your trainer. All observations will be made in situ (*i.e*. do not remove any of the apparent hairs/fibers from the tape lifts).Examine circled apparent hairs/fibers, note the relevant features, and answer the Three Key Questions (listed in Topics). Use reflected and transmitted stereomicroscope exams. Observe the apparent hairs/fibers (still on the tape lifts) under the light microscope.

4 INVESTIGATIVE EXAMS

4.1 OBJECTIVES

- To learn to categorize a human hair to a specific somatic origin.
- To learn the historical classification of human hairs into anthropological groupings.
- To learn to identify different types of acquired characteristics, hair diseases, and atypical features of hairs.

4.2 TOPIC AREAS

1. Somatic Origin
    a. Head
    b. Pubic
    c. Beard/Mustache
    d. Body
    e. Eyebrow/Eyelash
    f. Axillary
2. Racial characteristics (for Historical Purposes)
    a. Anthropological categories
        i. Caucausoid
        ii. Negroid
        iii. Mongoloid
    b. Microscopic characteristics
        i. Cuticle
        ii. Pigmentation
        iii. Cross sectional shape
        iv. Diameter
        v. Twisting
3. Acquired Characteristics
    a. Damage
        i. Angle cut
        ii. Crushed
        iii. Glass cut
        iv. Insect
        v. Straight cut
        vi. Sun
        vii. Thermal
    b. Forcibly removed
    c. Color alterations
        i. Bleaching
        ii. Dyed
    d. Decompositional Changes
        i. Discoloration of root or proximal end
        ii. Postmortem root banding
        iii. Tapered appearance of root or proximal end

iv. Brush-like appearance of root or proximal end
v. Fungal tunneling

e. Adherent materials
i. Blood
ii. Hair Products
1. Conditioners
2. Detanglers
3. Luster enhancers
iii. Lice / Nits
iv. Makeup
v. Seminal fluid

4. Diseases
a. Monilethrix (beaded swelling)
b. Pili annulati (abnormal diameter)
c. Pili torti (twisted shaft)
d. Trichorrhexis nodosa (beaded swellings)
5. Gray hair
6. Atypical microscopic features
a. Fusiforms
b. Looped cuticle

4.3 READINGS

1. Current Hair Analysis chapter from the Materials Analysis Technical Procedures Manual.
2. ASTM E3316-22 Standard Guide for Forensic Examination of Hair by Microscopy [read section 3. Terminology].
3. Appel O and Kollo I **(2010)** “The evidential value of singed hairs in arson cases” in *Science and Justice* 50: 138-140.
4. Bisbing RE **(2020)** “The forensic identification and association of human hair”. In Richard Saferstein (Ed.) *Forensic Science Handbook, Volume I, Third Edition* (pp 151-200) CRC Press, Taylor & Francis Group. [Note: read subsections from Cuticle through Distal Tips (pp 155-160), subsections from Racial Origin through Disease (pp 165-171).]
5. Bogarty H **(1969)** “Differences between adult and children's hair” in *Journal of the Society of Cosmetic Chemistry* 20:159-171.
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11. Harding H and Rogers G **(1999)** "Physiology and growth of human hair". In James Robertson (Ed.) *Forensic Examination of Hair* (pp 1-77) London, UK: Taylor and Francis. [Note: read only sections 1.7.2 Morphology (pp 47-49)]
12. Hietpas J, Buscaglia J, Richard AH, Shaw S, and Castillo HS **(2016)** "Microscopical characterization of known postmortem root bands using light and scanning electron microscopy" in *Forensic Science International* 267: 7-15.
13. Igowsky K and Pangerl E **(2015)** "Changes observed in human head hairs exposed to heat" in *Journal of American Society of Trace Evidence Examiners* 6(2): 17-26.
14. Hicks JW **(1977)** *Microscopy of Hairs A Practical Guide and Manual*, FBI Laboratory Technical Supplement, FBI, Washington D.C. [Note: read only Human Hairs (pp 6-27).]
15. Keogh EV and Walsh RJ **(1965)** "Rate of greying of human hair" in *Nature* 207: 877-878.
16. Koch SL, Michaud AL, and Mikell CE **(2013)** "Taphonomy of hair – a study of postmortem root banding" in *Journal of Forensic Science* 58(Supp 1): S52-S59.
17. Nelson D and DeForest P **(1999)** "Forensic examination of hairs for cosmetic treatment". Chapter 6 in James Robertson (Ed.) *Forensic Examination of Hair* (pp 229-242) London, UK: Taylor and Francis.
18. Ogle RR and Fox MJ **(1999)** *Atlas of Human Hair Microscopic Characteristics* New York, CRC Press. [Note: read only chapter 3 Human Hair Microscopic Characteristics (pp15-31), chapter 5 Human Hair Microscopic Characteristics: Photographs and Drawings of Variate Archetypes and Examples (pp 37- 48, plates), and the Glossary (pp 57-63).]
19. Petraco N and Kubic T **(2004)** *Color Atlas and Manual of Microscopy for Criminalists, Chemists, and Conservators* New York: CRC Press. [Note: read only Identification and Comparison of Human Hair (pp 57-67) and Appendix A: Human Hair Atlas (pp217-237).]
20. Richard AH, Hietpas J, Buscaglia J, and Monson KL **(2019)** "Timing and appearance of postmortem root banding in nonhuman mammals" in *Journal of Forensic Sciences* 64(1): 98-107.
21. Robbins CR **(1988)** "Morphological and macromolecular structure". In *Chemical and Physical Behavior of Human Hair, Second Edition* (pp 1-38) New York: Springer-Verlag. [Note: read only Abnormalities (pp 31-35).]
22. Robbins CR **(1988)** "Bleaching human Hair". In *Chemical and Physical Behavior of Human Hair, Second Edition* (pp 102-121) New York: Springer-Verlag. [Note: read only Hair Pigment Structure and Chemical Oxidation (pp 110-111) and Physical Properties of Bleached Hair (p 119).]
23. Robertson J **(1999)** "Forensic and microscopic examination of human hair". In James Robertson (Ed.) *Forensic Examination of Hair* (pp 79-154) London, UK: Taylor and Francis. [Note: read only sections 2.4 Human Hair (pp 84-120).
24. Rowe WF **(2010)** "Extreme degradation of human hair by keratinophilic and keratinolytic fungi" in *The Microscope* 58(3): 115-119.
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26. Trejos T, Koch S, and Mehltretter A **(2020)** "Scientific foundations and current state of trace evidence – A review" in *Forensic Chemistry* 18: article 100223. [Note: read section 5 hair subsection 5.1.2 Ancestry.]

27. Wilkinson L, Bailey JW, and Gwinnet C **(2020)** "The creation of an assessment tool for the analysis of two forms of heat damage in animal hair" in *Forensic Science International* 312: article 110265.

4.4 STUDY QUESTIONS

1. How does shouldering differ from a triangular cross-section shaped hair?
2. What is the difference between hair shaft undulation, twisting, and diameter variation?
3. Describe the "typical" microscopic features observed for the following somatic types:
   a. Head
   b. Pubic
   c. Chest
   d. Underarm
   e. Limb (arm, leg)
   f. Facial (beard, mustache)
   g. Eye (eyebrow, eyelash)
4. What is a nit?
5. What is a cracked cuticle?
6. What is a fungal tunnel?
7. What is a fusiform?
8. How can you tell the difference between natural (*i.e.* sun) and artificially bleached hair?
9. How do you tell the difference between a bleached hair and a gray hair?
10. What is necrosis?
11. What features may be present on a necrotic root?
12. Can you distinguish hair from an adult and hair from a child? Explain.
13. Describe the appearance of a heat-damaged and burned hair.
14. Discuss with your trainer:
    a. The methods for dyeing hair, including over the counter hair dyes, hair salons, and Kool-aid.
    b. The historical categorization of hairs based on anthropological characteristics.
    c. The composition and detection of hair products.

4.5 PRACTICAL EXERCISES

1. Observe a set of known hairs from different somatic origins. Include different racial sources where possible. Perform visual, stereomicroscope, light microscope, and polarized light microscope exams. Note the widest diameter, the degree of diameter fluctuation, buckling, continuity of the medulla, optical cross section, and adherent materials.
2. Observe a set of known color altered hairs. Perform visual, stereomicroscope, light microscope, and polarized light microscope exams. Note lines of demarcation, the cortical texture differences at the proximal and distal ends, changes in pigmentation density, thickness and color of cuticle. How do these color changes differ from banding in animal hairs?

3. Observe a set of known hairs with damage. Perform visual, stereomicroscope, light microscope, and polarized light microscope exams. Note any changes in overall width and changes in the appearance of the different layers in the damaged regions.
4. Observe a set of known hairs with adherent materials. Perform visual, stereomicroscope, light microscope, and polarized light microscope exams. Note the appearance (shape, color, luster, and birefringence) of the adherent materials.
5. Observe the roots of naturally shed and forcibly removed head hairs. To collect naturally shed hairs, run your fingers loosely through your hair over a piece of paper. To collect forcibly removed hairs, pull individual hairs using different amounts of force (speed). For the visual and stereomicroscope exams, be sure to examine each hair on a black background and on a white background. For the light microscope exams, be sure to adjust the condenser aperture to observe the “ruffled” appearance of tissue sheaths.
6. Observe a set of unknown samples provided by your trainer. Perform whatever exams are necessary to characterize each unknown apparent hair/fiber. Use the trainer provided worksheet to identify various features.

5 TRANSFERENCE, PERSISTENCE, AND RECOVERY

5.1 OBJECTIVES

- To develop an understanding of transference and persistence of hairs
- To practice recovery methods for hairs.

5.2 TOPIC AREAS

1. Transference
   a. Mechanisms
      i. Growth Rates
      ii. Hair Distribution Patterns
      iii. Natural Shedding
      iv. Forcibly Removed
   b. Primary Transference
      i. Distribution Patterns
      ii. Distance
   c. Secondary Transference
2. Persistence
3. Recovery
   a. At the Scene versus at the Lab
   b. Substrate Types
      i. Fabric Construction (Clothing/Bedding/Upholstery)
      ii. Shoes (Soles/Laces/Interior)
      iii. Tools (Handheld/Power)
      iv. Interior Flooring (Carpeting/Wood/Vinyl)
      v. Roadways (Roads/Driveways/Parking Lots)
      vi. Outdoors (Lawn/Garden/Forest)
      vii. Vehicles (Cars/Bicycles)
4. Choice of Recovery Method
   a. Picking
   b. Taping
   c. Scraping
   d. Vacuuming
5. Potential of Other Evidence in Sample
6. Choice of Packaging
   a. Type of Packing Material
   b. Presence of Other Evidence
7. Screening Large Numbers
   a. Grouping
   b. Targeting
   c. Crushed during handling

5.3 READINGS

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13. Trejos T, Koch S, and Mehltretter A **(2020)** "Scientific foundations and current state of trace evidence – A review" in *Forensic Chemistry* 18: article 100223. [Note: read section 5 hair subsection 5.2 Transfer and persistence studies.]

5.4 STUDY QUESTIONS

1. About what percentage of the time does a suspect transfer pubic hair to a victim's pubic area during a sexual assault? About what percentage of the time does a victim transfer pubic hair to a suspect's pubic area during a sexual assault?
2. About what percentage of the time does a suspect transfer head hairs to a victim's underwear during a sexual assault? Suspect transfer of pubic hairs? About what percentage of the time does a victim transfer head hairs to a suspect's underwear? Victim transfer of pubic hairs?
3. About what percentage of the time does a suspect transfer head hair to the outer clothing of a victim during a sexual assault? About what percentage of the time does a victim transfer head hair to the outer clothing of a suspect during a sexual assault?
4. About how long do hairs persist on outer clothing?

5. How does the pattern of rate of hair loss differ between wool and non-wool fabrics?
6. Can hairs from the inside of shirt move to the outside of the shirt when the shirt is shipped from the police agency to the laboratory?
7. If a body is found with hair in the victim's hands, is the hair likely from the suspect or the victim?
8. About how many hairs might one expect to pick up from their environment during a normal day?
9. From whom might you expect to pick up hairs in your normal environment?
10. Would there be a difference in significance between a small number of hairs transferred onto a relatively clean garment versus a small number of hairs transferred to a garment covered with a multitude of other kinds of hairs?
11. How does laundering affect hair evidence?

5.5 PRACTICAL EXERCISES

1. Prepare a set of tape lifts from any fabric surface spiked with pulled hairs. Practice removing hairs from the tape lift and mounting on slides. Use xylene substitute. Practice until you don't lose the adherent root tissue and have removed most of the adhesive. Show your slides to your trainer. Remove the hairs and place on sticky notes with the root end on the paper below the adhesive line. Fold the sticky notes for protection and hand to your trainer for review.
2. Recover hairs from a worn (not new) baseball hat by picking. Be sure to examine interior folds. Preserve the hairs in a paper packet.
3. Seed a shirt with a known number and length of brightly dyed hairs. The shirt color should provide good contrast to the dyed hair color. Take the shirt off every hour and count the number of dyed hairs. Continue every hour for at least 8 hours or until there are no more dyed hairs present. Organize your data in a chart. How long did the hairs persist on the fabric? Note the tag information for fiber content. Was the fabric knit (stretchy) or woven (not stretchy)? Look around the areas you have been and note the transfer locations of any of the brightly dyed hairs.

6 EVIDENTIARY SIGNIFICANCE AND MOCK CASEWORK

6.1 OBJECTIVES

- To develop an understanding of the significance and limitations of hair analysis exams
- To demonstrate the ability to perform hair analysis casework
- To understand how to evaluate and generate additional requests for forensic analysis in the context of hair analysis
- To ensure appropriate documentation and report writing skills
- To ensure appropriate techniques and confidence for court presentation

6.2 TOPIC AREAS

1. Assessment of Submitted Evidence
2. Types of Exams
3. Technical Manual Requirements
4. Report Wording
5. Court Testimony
   a. Pencil Analogy
   b. History – Microscopic Comparisons

6.3 READINGS

1. Current Hair Analysis chapter from the Materials Analysis Technical Procedures Manual.
2. ASTM E3316-22 Standard Guide for Forensic Examination of Hair by Microscopy.
3. ABS Group **(2019)** “Root and cultural cause analysis of report and testimony errors by FBI MHCA Examiners”
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8. Kaye DH **(2015)** “Ultracrepidarianism in Forensic Science: The Hair Evidence Debacle” in *Washington & Lee Law Review Online* 72: 227-254.
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11. Norton J, Anderson W, and Divine G **(2016)** “Flawed forensics: statistical failings of microcroscopic hair analysis” in *Significance* 13(2) 26-29.

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14. Trejos T, Koch S, and Mehltretter A **(2020)** "Scientific foundations and current state of trace evidence – A review" in *Forensic Chemistry* 18: article 100223. [Note: read section 5 hair subsection 5.4 Discrimination and Interlaboratory Studies and subsection 5.5 Collections and Databases.]
15. Wickenheiser RA and Hepworth DG **(1990)** "Further evaluation of probabilities in human scalp hair comparisons" in *Journal of Forensic Sciences* 35(6): 1323-1329.

6.4 STUDY QUESTIONS

1. What types of evidence are submitted for hair analysis?
2. How should hair analysis evidence be stored?
3. What conclusions may be reached from a hair analysis?
4. Describe a time where hair screening would be more valuable than DNA analysis?
5. What information should be included in your notes?
6. What information should be included in a report?
7. Describe what a hair is to a jury using the pencil analogy.
8. Discuss with your trainer
    a. The history of microscopic hair comparisons and the attempts to use statistics in hair analyses.
    b. The "Shaving and Hair Growth" article by Lynfield and MacWilliams (1970) as an example of problems in hair research.

6.5 PRACTICAL EXERCISES

1. Review at least 5 case files. A representative file from each hair analyst should be included in the mix. Note the wording of observations, worksheets, and what printouts were included. Note how the conclusion(s) were documented.
2. Work at least 5 hair analysis mock cases as if they were real cases. These cases should be realistic in the type of evidence submitted. At least one of the mock cases should include a request for investigative information, a request for suitable of DNA, hairs mounted on tape lifts, and trace recovery with a large quantity of hairs. Follow the requirements of the Technical Manual and include a draft report.
3. Perform at least 3 practice technical reviews. These reviews may be on copies of active hair analysis case files prior to the actual case files undergoing technical review by a qualified analyst or on mock hair analysis case files created for this exercise.
4. Discuss with your trainer and other hair analysts any unusual casework they have had. Document your conversation with notes.
5. Discuss with your trainer and other hair analysts any court testimony experiences they have had. Document your conversations with notes.
6. Observe court testimony in hair analysis if possible. Document your observations with notes.
7. Participate in an oral practice session to practice giving verbal answers to court type questions for hair analysis. Documentation will include a written list of questions asked provided by your trainer <u>after</u> the practice session.

7 HAIR ANALYSIS TRAINING CHECKLIST

Trainer Name: **Trainee Name:**	Trainee Initials/Date	Trainer Initials/Date	Time for Completion
Introduction			
Location of Reference Materials on Portal			
Basic Physiology and Anatomy			
Reading			
Study Questions			
Exercises			
Suitability for DNA Exams			
Reading			
Study Questions			
Exercises			
Investigative Exams			
Reading			
Study Questions			
Exercises			
Transference, Persistence, and Recovery			
Reading			
Study Questions			
Exercises			
Evidentiary Significance and Mock Casework			
Reading			
Study Questions			
Exercises			
Written Test			
Competency Exam			
Oral Testimony Exam			