Forensic Human Hair Examination Training Program

Scientific Working Group for Materials Analysis (SWGMAT)
Hair Subcommittee

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Chapter 1 Introduction and User's Guide

Scope of Guidelines

This training manual is intended as a guide for use by laboratories responsible for training forensic hair examiners to prepare them to perform microscopical examinations. It contains relevant suggested reading assignments and structured exercises for hands-on practical experience for the trainee. Other sources of information on forensic hair examination, not specifically mentioned in this manual, can be considered, added, or substituted where justified. Additional training beyond that which is listed here should be made available to the trainee when possible. Such training might include off-site short courses, short internships, and special training by experienced examiners. Continuing education and training should not be limited to the training period, as the trainer cannot dictate the availability and cost of such courses. Additional training will provide a hair examiner the opportunity to remain current in the field. Other analyses may be performed on hairs that have been chemically altered or have trace materials on the surface, such as dyed hairs or hair care products. These techniques are beyond the scope of these guidelines because they are not generally applicable.

This manual is in a modular format for easy adaptation to an individual laboratory's training programs. Suggestions as to lessons, practical exercises, progress monitoring, and trainee evaluation are included. Reading assignments with full citations are listed in each subsequent chapter of this document.

A training program should provide a theoretical foundation and basic practical skills to prepare a trainee to become a fully qualified forensic hair examiner. At the end of the training program, the trainee, under direct supervision of a fully qualified examiner, should be capable of forming opinions based upon sound scientific knowledge, proper examinations, and practical experience.
The training manual is intended to complement the SWGMAT Forensic Human Hair Examination Guidelines which can be obtained from *Forensic Science Communications*, January 2005, www.FBI.gov.

Educational Prerequisites

Refer to SWGMAT Trace Evidence Quality Assurance Guidelines, Section 4.3

Training Program Objectives

With completion of this training program, the trainee should have gained the theoretical knowledge and practical skills needed with respect to hair examinations and comparisons. Topics should include:

1. **Occurrence, transfer, and persistence of hairs**
2. **Evidence recovery methods**
3. **Evidence handling to minimize contamination and loss**
4. **Evidence packaging and documentation**
5. **Use and maintenance of microscopes**
6. **Understanding of hair chemistry, biology, structure, and function**
7. **Recognition of diseases manifested in hairs**
8. **Recognition of mechanical damage, environmental effects, and chemical treatments used on hair**
9. **Identification and classification of hairs**
10. **Comparison of questioned and known hairs**
11. **Other analytical techniques (DNA)**
12. **Interpretation of comparison results**
13. **Preparation of laboratory reports**
14. **Presentation and interpretation of results in court**

Training Steps and Schedule

Training guidelines should give the trainee theoretical knowledge and practical skills in forensic hair examination and interpretation. This can be accomplished through a combination of the following training methods:

1. **Reading of relevant literature**
2. **Instruction and observation of hair examiners**
   - **Lectures and discussions**
   - **Practical demonstration of basic skills**
   - **Casework**
   - **Court testimony**
3. **Practical skills**
   - **Practical exercises**
   - **Assisting in and performing supervised casework**
4. **Examinations and tests**
   - **Written or oral tests**
   - **Practical laboratory tests**
5. **Competency evaluation**

The recommended training period is approximately one year, full time, for an inexperienced forensic examiner. For the purpose of this document, an inexperienced examiner is an individual who has little knowledge in trace

evidence, minimal microscopy knowledge, or minimal knowledge of hair evidence and comparison. A trainee with experience in other areas of forensic science may have knowledge in microscopy, in other areas of trace evidence, or in court testimony; and, therefore, may not require such an extensive training regimen.

Records of Training

Each stage of the training process for each trainee should be documented, reviewed, and maintained according to individual laboratory guidelines.

Responsibilities

Each trainee should be trained by and work under the guidance of one or more experienced forensic hair examiners. The trainer(s) must be technically competent in the field of hair examination and comparison.

The trainer may be responsible for:

- **Introducing the trainee to the relevant scientific literature, proper procedures, training material, and reference collections**
- **Discussing readings and theory with the trainee**
- **Teaching basic methods**
- **Teaching case management**
- **Fostering ethical and proper professional conduct through discussion and by setting an example**
- **Teaching appropriate quality assurance and quality control procedures**
- **Reviewing tests, practical exercises, and casework samples with trainee**
- **Teaching expert testimony skills through moot court and/or observation**

The trainer and supervisor should monitor the trainee's progress. The training must be thorough and complete to ensure the trainee becomes a competent analyst. Other members of the laboratory should be encouraged to offer relevant information regarding their specialties to the trainee.

The trainee is expected to meet the objectives set forth in the training program by:

- **Self-study of reading materials**
- **Practicing of basic skills**
- **Using practical exercises**
- **Successful completion of written and oral tests**
- **Observation of case work being conducted by an experienced examiner**
- **Observation of court testimony given by an experienced examiner**
- **Conducting themselves in an ethical and professional manner**
- **Participating in the quality assurance and quality control program of laboratory**

- **Successful completion of competency tests in identification and comparison**
- **Competent performance of supervised casework**
- **Demonstrate ability to accurately and effectively communicate hair findings in court through court testimony monitoring and/or transcript review**

Each laboratory is responsible for maintaining:
- **An up-to-date training program**
- **Documentation of competency tests and proficiency tests**
- **Training documents**
- **Documentation of court testimony**

Training Program Details

The Table of Contents outlines a suggested training program by chapter and section. Individual laboratories may use this and tailor it to their own needs.

Each chapter is divided into sections that include general discussions of the subject of that particular chapter; the objective to be gained by learning that particular subject; the relevant readings; practical applications of the knowledge gained; and when appropriate, testing of the trainee's knowledge and skills.

Reading assignments are selected to give the trainee a sound theoretical background in topics necessary for hair analysis. Reading assignments are required, and may also be supplemented by additional suggested readings.

Essential skills should be demonstrated by the trainer and practiced by the trainee so that such skills can be acquired and performed competently.

Practical exercises should be designed to allow the trainee to learn and practice the skills needed to perform casework. The trainer should review the trainee's performance during the exercises. Satisfactory completion of the exercises should be documented.

Written or oral tests along with practical laboratory tests are recommended as a means of determining the trainee's comprehension of the material and as a means to document the training. Questions should be designed to test the trainee's theoretical and practical knowledge. A pass criterion should be established at the beginning of the training program. Contingencies for not passing a test must also be in place. The trainer should address deficiencies through additional readings and training.

Initially, the trainee should assist an experienced hair examiner in all aspects of casework. This helps the trainee understand the various aspects of casework including record keeping; processing of evidence; sample preparation; microscopical study of prepared specimens; characterization, identification,

comparison, and interpretation of hair evidence. The experienced examiner should provide guidance to the trainee; however, the examiner must perform all case examinations and comparisons and is responsible for all conclusions.

When the trainer, trainee, and supervisor conclude that the trainee is competent and sufficiently practiced, the trainee can proceed to supervised casework. The trainer or case supervisor must verify all laboratory results obtained by the trainee. At the end of the training program, the trainee should be ready to analyze cases and compare hairs independently. The results should then be reviewed in accordance with laboratory quality assurance procedures.

A comprehensive competency test must be administered prior to the trainee analyzing and comparing hair cases independently. The test should be designed to mimic actual casework, requiring the trainee to demonstrate his/her knowledge of the laboratory's procedures in handling evidence, taking notes, maintaining chain of custody, and writing a report, as well as the actual comparisons of hair evidence.

The trainee should attempt to observe experienced examiners testifying in court as often as possible. The trainee should pay attention to general courtroom procedures, the witness's appearance and demeanor, and the presentation of technical or expert knowledge. After each observation, the trainee and this examiner should discuss the courtroom experience.

A moot court experience should be given to the trainee. The trainee's moot court should be challenging and mimic as closely as possible a real courtroom experience. The trainee should be evaluated on appearance, demeanor, knowledge of the case, knowledge of the discipline, scientific accuracy, and presentation skills.

The trainee's progress should be continually monitored according to objective criteria established by the laboratory. Periodic progress assessments involving the trainee, trainer, and supervisor should be conducted. Deficiencies in the trainee's performance should be addressed immediately. Remediation should be made available through additional training, practice, or a re-evaluation of the training program. Continued deficiencies may suggest the unsuitability of the trainee for casework in this area.

Training Course Evaluation

The trainee should be given a chance to evaluate the hair-training program and the trainer. Perceived deficiencies in the training program or the trainer should be addressed.

Evaluation and Certification of Competency

Upon successful completion of the training program, the trainee should receive a certificate or letter of competency in forensic hair analysis. After receipt of such certification, the trainee will be allowed to perform independent casework including forensic hair comparisons.

Chapter 2 Casework Familiarization, Search, and Recovery of Hair Evidence

General Discussion

This module will introduce the trainee to the proper documentation needed in casework and to the proper methods of detection, collection, and preservation of trace evidence from crime scenes and from items submitted to the laboratory. This training should expose the trainee to evidence handling issues such as:

- **Deposition**
- **Transfer**
- **Persistence**
- **Contamination**
- **Loss of trace evidence**

An attempt should be made to expose the trainee to a variety of trace evidence cases and analyses throughout the training period. This module should include observation and practice by the trainee.

Objectives

In this module, the trainee will gain knowledge in:

- **The proper procedures for case documentation**
- **The recognition of hair and other evidential materials and the evaluation of their significance in a particular case**
- **Detection, collection, and preservation techniques appropriate to the different types of trace evidence including hairs**
- **Loss, transfer, and persistence of trace evidence**
- **Prevention of contamination and/or loss in handling hair evidence**
- **The proper procedures in the laboratory for maintaining the chain of custody of the original evidence and any trace evidence collected**
- **The safety procedures in the laboratory for the handling of potentially biohazard materials**
- **The documentation of analytical results, as required by the trainee's laboratory**

Training Steps

1. **Recommended Reading Assignments:**

- **American Society for Testing and Materials. "Standard Guide for Physical Evidence Labeling and Related Documentation". In: *The Annual Book of ASTM Standards*, Section 14, E1492-92. West Conshohocken, PA: American Society for Testing and Materials. 2005.**

- **American Society for Testing and Materials. "Standard Practice for Receiving, Documenting, Storing, and Retrieving Evidence in a Forensic Science Laboratory". In: *The Annual Book of ASTM Standards*, Section 14, E1492-92. West Conshohocken, PA: American Society for Testing and Materials. 2005.**
- **Bisbing, R., "The Forensic Identification and Association of Human Hair". In: *The Forensic Science Handbook*, 2nd edition, volume 1:390-428 (chapter 5). Upper Saddle River, New Jersey: Pearson Education. 2002.**
- **Inman, K. and Ruden, N., *Principles and Practice of Criminalistics, the Profession of Forensic Science*, chapters 4, 5, 9, and 10. Boca Raton: CRC Press. 2001.**
- **Malcolm, M. and Peel, H., "Introduction to Accreditation of Forensic Laboratories", version 1.0. 2004.**
- **Robertson, J., "Forensic and Microscopic Examination of Human Hair". In: *Forensic Examination of Hair*, chapter 2. London: Taylor and Francis. 1999.**
- **Robertson, J. and Springer, F., "From the Crime Scene to the Laboratory". In: *Forensic Examination of Fibres*, 2nd edition, chapters 5.1 and 5.2. London: Taylor and Francis. 1999.**
- **SWGMAT. 2000. "Trace Evidence Quality Assurance Guidelines". In: *Forensic Science Communications*, volume 2, no. 1 accessed at http://www.fbi.gov/hq/lab/fsc/backissu/jan2000/swgmat.htm**
- **SWGMAT. 1999. "Trace Evidence Recovery Guidelines". In: *Forensic Science Communications*, volume 2, no. 3 accessed at http://www.fbi.gov/hq/lab/fsc/backissu/oct1999/trace.htm**

2. **Instruction and Observation:**
   The trainee should observe hair casework, from the assignment of a case through an examination to the preparation of a report. The trainer should discuss all aspects of casework with the trainee, explaining each step as the case is processed. Instruction will be given in the following topics:
   - **Documentation required for a case file**
   - **Description and labeling of evidence**
   - **Procedures required to maintain chain of custody**
   - **Procedures to prevent contamination and loss**
   - **Procedures to clean and control the laboratory environment**
   - **Selection of the appropriate detection, collection and preservation techniques for hair and other trace evidence**
   - **Designation of evidence as questioned or known samples**
   - **Collection of representative known samples**
   - **General laboratory protocols**
   - **Health and safety hazards**
   - **Laboratory quality assurance procedures**

3. **Practical Exercises**
   Trainee should practice processing a variety of items for trace evidence. Skills practiced should include:

- **Different techniques of recovery (e.g., scraping, tape lifting, vacuuming, picking)**
- **Packaging and preserving evidence**
- **Experience in the collection of known or reference materials. Mock "evidence" should be provided by the trainer to practice collection techniques.**

4. **Supervised casework**
   As training progresses, the trainee can be assigned selected cases to process for the purpose of recovering and safeguarding trace materials of evidential value. Under the direct supervision of the trainer, the trainee should then practice the techniques and procedures required to:
   - **Create and organize a case file**
   - **Process a case for trace materials**
   - **Safeguard evidence**

5. **Examinations and tests**
   Tests can be given to the trainee to evaluate the acquired knowledge and skills covered in this chapter.

6. **Competency Evaluation**
   The trainer should evaluate the competency of the trainee to utilize the techniques needed to find and recover trace evidence. The trainee should be able to choose the appropriate evidence recovery technique. The trainer should also evaluate the trainee's knowledge of proper laboratory procedures for creating a case file, handling evidence safely, and labeling evidence.

Chapter 3 Microscopy Review

General Discussion

This module will introduce the trainee to the theory and basic procedures and techniques for the proper operation of a stereomicroscope, a polarized light microscope, and a transmitted light comparison microscope. The care and maintenance of these microscopes will also be discussed.

Objectives

In this module, the trainee will gain knowledge in:

- **Why different types of microscopes are used in hair analysis**
- **How microscopes work (theory)**
- **The proper operation and maintenance of the different types of microscopes**
- **Setting up Köhler (or modified Köhler) illumination**
- **The proper selection of mounting media**

Training Steps

1. Reading Assignments

- **Instruction books for the microscopes used in your laboratory**
- **McCrone, W., McCrone, L. and Delly, J., *Polarized Light Microscopy*. Ann Arbor, Michigan: Ann Arbor Science Publishers, Inc. 1978.**
- **DeForest, P., "Foundations of Forensic Microscopy". In: *The Forensic Science Handbook*, 2nd edition, pp 215-320. Upper Saddle River, New Jersey: Pearson Education. 2002.**

2. Practical Exercises

- **Familiarization with the polarized light microscope and the transmitted light comparison microscope**
- **Check the alignment of the condenser, the stage and the objectives on both the comparison microscope and the polarized light microscope.**
- **Check the color balance and magnification balance on the comparison microscope**
- **The trainer should demonstrate how to properly set up Köhler (or modified Köhler) illumination. The trainee should employ this technique when using the microscope.**
- **Calibrate the eyepiece micrometer for all objectives on both the polarized light microscope and the comparison light microscope**
- **Selection of mounting media**
  - **The trainee should mount several hairs using different temporary and/or semi-permanent mounting media.**

- **The trainee should know the refractive index of the mounting media used and measure the relative refractive index of human hair to each of the media (greater or less than the medium).**
- **The trainee should experiment with different refractive index media to see which gives the best detail in different parts of the hair.**

- **Evaluation of effective cover slip thickness**
  - **The trainee should mount several hairs using different cover slip thicknesses and different mounting medium thicknesses. The trainee should experiment with different thicknesses of each to see which gives the best image in different levels or depths within the preparation.**
- **Color balance of the comparison microscope**
  - **The trainer shall demonstrate to the trainee how to properly balance the background color on both sides of the comparison microscope. The trainee should then practice this technique. Refer to SWGMAT Forensic Human Hair Examination Guidelines, section 8.4.2.3, for color balancing techniques.**
  - **The trainee should experiment with and understand the effect of different colored contrast filters and neutral density filters.**
- **Polarized light microscope exercises**
  - **The trainee may study hairs under crossed polarized light to observe features such as the cross sectional shape of hairs, diameter or shaft variations, medullary features, hair damage, and visualizing cuticle features with quarter wave plate**

3. Competency Evaluation

The trainer should evaluate the knowledge and competency of the trainee through a written quiz or a practical test. After the microscope has been covertly misaligned and maladjusted, the trainee should be asked to properly set up a microscope, including achieving proper illumination, color and intensity balance of the light sources on the microscope(s).

Chapter 4 Introduction to Hairs – Human & Animal Hairs

General Discussion

This module will introduce the trainee to the fundamental biology, physiology and anatomy of hair, as well as the history of hair examination, and definitions of terms used in hair identification and comparison.

Objectives

In this module, the trainee will gain knowledge in:

- **The purpose and function of human and animal hair**
- **The structures of human and animal hair**
- **The growth of human hair**
- **The chemical composition of hair**
- **The history of hair examination**
- **Definitions of terms**
- **Identification of hair**

Training Steps

1. Reading Assignments

- **Robbins, C., *Chemical and Physical Behavior of Human Hair*, pp 1042. New York, New York: Springer-Verlag. 1988.**
- **Kaszynski, E., "Hair Growth: Mechanism and Regulation". From: *The Proceedings of the International Symposium on Forensic Hair Comparison*, pages 23-34. Washington, DC: Federal Bureau of Investigation, U.S. Government Printing Office. 1987.**
- **Deedrick, D. and Koch, S., 2004. "Microscopy of Hair Part 1: A Practical Guide and Manual for Human Hairs*".* In: *Forensic Science Communications*, volume 6, no. 1 accessed at http://www.fbi.gov/hq/lab/fsc/backissu/jan2004/research/2004_01_research01b.htm.**
- **Robertson, J., "Forensic and Microscopic Examination of Human Hair". In: *Forensic Examination of Hair*, introduction chapter. London: Taylor and Francis. 1999.**

2. Practical Exercises

- **The trainee should become familiar with the basic appearance of hair by utilizing a stereomicroscope with both incident and transmitted light. The trainee should observe several known human and animal hairs, making notations regarding the general appearance and characteristics that are visible under the lower power magnification.**

- **Examine hair utilizing a polarized light microscope with both plane polarized light and crossed polars. The trainee should examine the same known human and animal hairs, noting the greater number of characteristics visible in the mounted hairs under the higher magnification and polarized light.**
- **Classifying the basic root types**
  - **Remove several hairs from a used hair brush. Classify the roots.**
  - **Pull 20 or more head hairs from your head and one other person's head. Classify the roots.**
- **Using human and animal hairs; identify the cuticle, cortex, medulla, cortical fusi, ovoid bodies, and pigment granules, when present.**
- **Practice cross-sectioning. Discuss utility and precautions in using these techniques as to possible changes to the original evidentiary hair.**
- **Discuss utility and precautions of using scale casting techniques for example in influence to the retention of other debris on hairs.**
- **Examine synthetic wig-type fibers and human wig hairs.**
- **Practice documenting observations using the laboratory's examination forms, specifically the characteristics that enable the trainee to differentiate between human and animal hair.**

3. Competency Evaluation

The trainer should evaluate the knowledge and competency of the trainee through a written quiz or a practical test including drawing the microscopic features of a hair and defining the terms

Chapter 5 Animal Hairs - Introduction to the recognition of Animal Hairs

General Discussion

This module will introduce the trainee to the microscopic characteristics in animal hair with the goal of enabling the trainee to differentiate animal hair from human hair. This chapter will give the trainee an overview of different animal hair features which are used to determine the species and type of animal from which hair has originated. The trainee should become familiar with the identification schemes available in their laboratory and in literature, for the recognition of hairs typical of common animal families. This chapter will also introduce the trainee to the transfer and persistence of animal hairs. Separate in-depth training should be developed for the purpose of identifying and comparing animal hairs.

Objectives

In this module, the trainee will gain knowledge in:

- **Recognizing animal hair and hair types (e.g. guard and fur)**
- **Procedures to make scale casts or observe scale patterns**
- **Identifying and characterizing the differences in the microscopic characteristics between families of animals.**
- **Modes of transfer of animal hairs.**

Training Steps

1. **Reading Assignments**

- **Brunner, H. and Coman, B., *The identification of Mammalian Hairs.* Melbourne, Australia: Inkata Press. 1974.**
- **D'Andrea, F., Fridez, F. and Coquoz R., "Preliminary Experiments on the Transfer of Animal Hair During Simulated Criminal Behaviour". In: *The Journal of Forensic Sciences*, volume 43. 1998.**
- **Deedrick, D. and Koch, S., 2004. "Microscopy of Hair Part 1: A Practical Guide and Manual for Human Hairs". In: *Forensic Science Communications*, volume 6, no. 1 accessed at http://www.fbi.gov/hq/lab/fsc/backissu/jan2004/research/2004_01_research01b.htm**
- **Deedrick, D., 2000. "Hairs, Fibers, Crime and Evidence Part 1: Hair Evidence", *Forensic Science Communications*, volume 2, no. 3 accessed at http://www.fbi.gov/hq/lab/fsc/backissu/july2000/deedric1.htm**
- **Hicks, J., *Microscopy of Hair: A Practical Guide and Manual*, pp 28-40 (Federal Bureau of Investigation, Washington, D.C.:1977)**
- **Tridico, S., "Examination, Analysis, and Application of Hair in Forensic Science-Animal Hair". In: *Forensic Science Review*, volume 17(1):17-28. 2005.**

- **Tridico, S., "Hair of the dog: A case study". In: *Trace Evidence Analysis — More Cases in Mute Witnesses*, pp 27–52. Elsevier Academic Press: Amsterdam. 2004.**

3. Observation and Discussion

Under the direction of the trainer, the trainee should examine several types of human and animal hairs using macroscopical and microscopical techniques to study/evaluate the various characteristics that distinguish animal hair from human hair; such as the different medullary patterns, scales, roots, tips, color, banding, shape, and diameter.

The trainer should demonstrate and discuss the various procedures for making scale casts to the trainee.

4. Practical Exercises

- **Mount guard hairs and fur hairs, (underhairs), from several different animal types. Include at a minimum, dog, cat, rabbit, horse, cow, bear, rat, and deer hairs.**
- **Microscopically examine these known animal hairs for medullary structure, scale features and other microscopic characteristics, noting how they differ from human hairs and how they differ between animal families. Practice note taking on the characteristics observed under the microscope.**
- **Make scale casts of the entire length of both guard hairs and fur hairs using various techniques. Examine casts and describe scale patterns, noting the different characteristics.**
- **Repeat these exercises using hairs that are commonly used for apparel such as chinchilla, wool, llama, mink, etc.**
- **Compare all of the above prepared animal hairs to human hairs derived from different body areas.**

5. Competency Evaluation

The trainer should evaluate the competency of the trainee to differentiate human hairs from other animal hairs. The trainee should be given unknown hair samples to identify as either human or animal in origin.

Chapter 6 Characterization and Assessment of Human Hairs

General Discussion

This module will introduce the trainee to the microscopic characteristics of human hair. Certain characteristics are common to all hairs, while some characteristics are less common, and therefore, may be more significant when comparing questioned and known hairs. The observed characteristics are used to determine if a hair is human or animal, indicate somatic origin, and indicate possible racial group.

Objectives

In this module, the trainee will gain the knowledge needed to:

- **Identify macroscopic and microscopic characteristics of human hair**
- **Determine somatic origin**
- **Determine racial characteristics**
- **Identify cross-sectional shape**
- **Characterize tip features**
- **Characterize root features in order to assess growth phase and possible mode of separation from the follicle**
- **Identify acquired characteristics such as crushing, burning, etc.**
- **Identify diseases, abnormalities, cosmetic treatments and adhering trace materials**

Training Steps

1. Reading assignments

- **Robbins, C., *Chemical and Physical Behavior of Human Hair*, pp 45-51, 131-133, 139-145, 211-226, 233-239, 247-261, 263-264, and 277-288. New York, New York: Springer-Verlag. 1988.**
- **Deedrick, D. and Koch, S., 2004. "Microscopy of Hair Part 1: A Practical Guide and Manual for Human Hairs". In: *Forensic Science Communications*, volume 6, no. 1 accessed at http://www.fbi.gov/hq/lab/fsc/backissu/jan2004/research/2004_01_research01b.htm**
- **Robertson, J., *Forensic Examination of Hair*. London: Taylor and Francis. 1999.**
- **Bisbing, R., "The Forensic Identification and Association of Human Hair". In: *The Forensic Science Handbook*, 2nd edition, volume 1:390-428 (chapter 5). Upper Saddle River, New Jersey: Pearson Education. 2002.**

- **Petraco, N., Fraas, C., Callery, F., and DeForest, P., "The Morphology and Evidential Significance of Human Hair Roots". In: *The Journal of Forensic Sciences*, volume 33:68-76. 1988.**
- **Ogle, R. and Fox, M., *Atlas of Human Hair – Microscopic Characteristics.* Boca Raton, FL: CRC Press. 1999.**
- **Petraco, N. and Kubic, T., *Color Atlas and Manual of Microscopy for Criminalists, Chemists, and Conservators,* pp 57-67 (chapter 5). Boca Raton, FL: CRC Press. 2004.**

2. Observation and Discussion

The trainer and trainee should examine and discuss the distinguishing features of hairs from the different somatic regions of each racial group. The trainer should point out and discuss the microscopic characteristics observed to the trainee.

The trainer and trainee should examine and discuss hair subjected to various cosmetic and environmental conditions, abnormalities, hair in various growth phases, cosmetic treatment, and adhering debris.

The trainer should discuss laboratory procedures and techniques that are used to remove and analyze cosmetics and/or debris adhering to a hair.

The trainer and trainee should discuss the suitability of the hair for microscopic comparison.

3. Practical Exercises

- **Collect and examine (macroscopically and microscopically) the following known hairs from a number of individuals in the three racial groups as well as hairs from mixed race individuals.**
  - **Head**
  - **Pubic**
  - **Arm**
  - **Leg**
  - **Face**
  - **Chest**
  - **Axillary**
  - **Eyebrow**
  - **Eyelash**
  - **Transitional or fringe hairs of the above**

  These hairs should be examined with respect to length, thickness, medulla, pigmentation, spatial configuration, tip, root, structure, etc.

  A series of practical tests should be given to the trainee to identify the racial group and somatic region.

  The trainee should be able to verbalize those macroscopic and microscopic

characteristics that serve to distinguish different racial groups and somatic regions.

- **Cross-section representative hairs from each racial group and somatic origin. Cross-sectional shape should be translated to the microscopic longitudinal appearance of the hair.**

- **Examine hairs that have acquired characteristics and abnormalities. As many hairs as possible that represent the features listed in the "Forensic Human Hair Examination Guidelines" should be studied.**

- **The trainee should take notes and photographs of the various characteristics present in the observed hairs, as well as the visible similarities and differences between the different racial groups and somatic origins. The trainee is encouraged to consider preparing a personal reference collection of hairs exhibiting the variety of characteristics that can be encountered.**

4. Competency Evaluation

The trainer should evaluate the competency of the trainee to characterize human hairs as to possible racial group and somatic region. A final performance test illustrating racial characteristics and somatic region characteristics should be conducted prior to the trainee moving into the next training module.

Chapter 7 Hair Examinations – Comparison Microscopy

General Discussion

The scope of this module is to enable the trainee to conduct hair comparisons. A comparison is typically made between a questioned head or pubic hair and a representative known sample of head or pubic hairs. The trainee will learn what typically constitutes suitable hairs for comparison. The trainee will learn the importance of having a representative known sample and gain an appreciation for what constitutes a representative sample. The conclusions that may be drawn after a comparison is made will be discussed.

Objectives

In this module, the trainee will gain the ability to:

- **Evaluate the suitability for comparison of a questioned hair**
- **Evaluate the adequacy of a known hair sample for comparison purposes**
- **Make proper microscopical comparisons between questioned hairs and known hair samples.**
- **Reach a valid conclusion as to the possible source of a questioned hair**

Training Steps

1. Reading Assignments

- **Bisbing, R. "The Forensic Identification and Association of Human Hair". In: *The Forensic Science Handbook*, 2nd edition, volume 1:390-428 (chapter 5). Upper Saddle River, New Jersey: Pearson Education. 2002.**
- **SWGMAT. 2005. "Forensic Human Hair Examination Guidelines". In: *Forensic Science Communications*, volume 7, no. 2 accessed at http://www.fbi.gov/hq/lab/fsc/backissu/april2005/standards/2005_04_standards02.htm**
- **Bisbing, R., "Human Hair in Forensic Perspective". From: *The Proceedings of the International Symposium on Forensic Hair Comparison*, pages 35-50. Washington, DC: Federal Bureau of Investigation, U.S. Government Printing Office. 1987.**
- **Ogle, R. and Fox, M., *Atlas of Human Hair – Microscopic Characteristics.* Boca Raton, FL: CRC Press. 1999.**
- **Petraco, N. and Kubic, T., *Color Atlas and Manual of Microscopy for Criminalists, Chemists, and Conservators,* pp 57-67 (chapter 5). Boca Raton, FL: CRC Press. 2004.**
- **Robertson, J., *Forensic Examination of Hair*. London: Taylor and Francis. 1999.**

- **Deedrick, D. and Koch, S., 2004. "Microscopy of Hair Part 1: A Practical Guide and Manual for Human Hairs". In: *Forensic Science Communications*, volume 6, no. 1 accessed at http://www.fbi.gov/hq/lab/fsc/backissu/jan2004/research/2004_01_research01b.htm**

2. Observation & Discussion

The trainee should observe the trainer performing a hair comparison. The trainer should explain to the trainee what constitutes an adequate representative sample. The trainer should explain the process of comparison and the significance of the characteristics observed while comparing two samples. The criteria for arriving at possible conclusions resulting from a comparison should be discussed.

3. Practical Exercises

- **Variations within a known hair sample**
  - **Collect both a combed and pulled hair sample from a known source; at least 20-25 hairs from different areas of the head and pubic region. These should first be observed with the unaided eye, and then with the stereomicroscope. All of the hairs should then be mounted and examined using the light microscope and the polarized light microscope. The similarities and differences within the known hair sample should be noted. The trainee should evaluate the variation in color, diameter, medullation, and scale features observed along the length of single hairs and among hairs within the sample. This exercise should be repeated a minimum of four (4) times with hairs from other known sources, preferably from individuals of different racial groups.**
  - **Examine the above reference samples for examples of the microscopic characteristics listed in the SWGMAT Forensic Human Hair Examination Guidelines, section 10.4.2. The trainee should attempt to find an example of each of the listed microscopic features.**

- **Performing hair comparisons**
  - **The trainee should select a single hair from each of the known samples collected above, compare this hair to its known source, and compare this hair to all other collected known hair samples.**
  - **The trainer should provide the trainee with known hair samples from individuals with similar hair coloring and length for comparison exercises.**
  - **The trainee should perform at least ten head hair and ten pubic hair comparisons from each of the different racial groups. Then the trainee should be given blind samples provided by the trainer to ensure that the trainee can correctly identify the source of the questioned hair. If there are any errors, these comparisons should be revisited with the trainer in order to determine why an incorrect conclusion was made.**

These exercises are designed to give the trainee confidence in the ability to differentiate between hairs from different sources.

4. Competency Evaluation

Once the trainee and the trainer feel confident in the trainee's ability to accurately compare hair samples, a challenging practical test should be administered to evaluate the trainee's ability in performing hair comparisons.

Chapter 8 Hair and DNA

General Discussion

This module will introduce the trainee to the application of DNA technology to hair analysis. Anagen hairs or other hairs with tissue may be suitable for nuclear DNA (nDNA) analysis. All hairs contain mitochondrial DNA (mtDNA). Current technologies make possible the extraction of DNA for analysis from a hair sample. Even if not performing DNA analyses, the trainee should be familiar with the criteria for determining suitability of a hair for nDNA or mtDNA analysis. Nuclear DNA analysis is much more discriminating than mitochondrial DNA analysis. When appropriate, nDNA is recommended because of its discrimination power and availability in most laboratories.
If a hair is not suitable for nDNA, mtDNA is recommended when the source of the hair is crucial to the investigation. Because of the limited discrimination power of mtDNA, a combination of mtDNA and comparison microscopy is required. Microscopy should always be conducted prior to any DNA analysis.

Objectives

In this module, the trainee will learn:
- **Basic knowledge of forensic DNA analysis**
- **The criteria for suitability of a hair for nuclear or mitochondrial DNA analysis**
- **Significance of the nDNA and mtDNA results**
- **Complementary nature of comparison microscopy and mtDNA testing**

Training Steps

1. Reading Assignments
- **Wilson, M., Polansky, D., Butler, J., DiZinno, J., Replogle, J., Budowle, B., "The Extraction, PCR Amplification and Sequencing of Mitochondrial DNA from Human Hair Shafts". In: *BioTechniques*, volume 18(4):662-669. 1995.**
- **Linch, C., Smith, S. and Prahlow, J., "Evaluation of the Human Hair Root for DNA Typing Subsequent to Microscopic Comparison". In: *The Journal of Forensic Sciences*, volume 43(2):305-314. 1998.**
- **Melton, T., Dimick, G., Higgins, B., Lindstrom, L. and Nelson, K., "Forensic Mitochondrial DNA Analysis of 691 Casework Hairs". In: *The Journal of Forensic Sciences*, volume 50(1):73-80. 2005.**
- **Houck, M. and Budowle, B., "Correlation of Microscopic and Mitochondrial DNA Hair Comparisons". In: *The Journal of Forensic Sciences*, volume 47(5):964-967. 2002.**

- **Houck, M., Bisbing, R., Watkins, T. and Harmon, R., 2004. "Locard Exchange: The Science of Forensic Hair Comparisons and the Admissibility of Hair Comparison Evidence: Frye and Daubert Considered". In: *Modern Microscopy Journal accessed at* http://www.modernmicroscopy.com/main.asp?article=36**
- **Robertson, J., *Forensic Examination of Hair*. London: Taylor and Francis. 1999.**
- **Houck M. and Bisbing R., "Forensic Human Hair Examination in the 21st Century". In: *Forensic Science Review*, volume 17(1):51-66. 2005.**
- **Yoshino, M., Sato, H. and Seta, S., "Hair: Deoxyribonucleic Acid Typing". In: Seigel, J., ed. *Encyclopedia of Forensic Sciences*, pp 1025-1032. London: Academic Press Ltd., 2000.**

2. Discussion

The trainer and the trainee should discuss how to determine the suitability of a hair for nDNA or mtDNA analysis. Certain characteristics, such as root type, cellular debris, and hair length, affect the suitability for DNA analysis. The trainer should discuss the complementary nature of the two techniques and the significance of each.

3. Practical Exercises

The trainer and trainee should examine and discuss numerous hairs in regard to their suitability for DNA analysis. The trainee should also gain practice photographing the root area for documentation purposes.

If available, review results of DNA analyses and microscopical conclusions that have been reached on the same hairs in prior cases in order to gain experience on determining which hairs are most suitable for DNA analysis. Discuss the significance and complementary nature of each.

4. Competency Evaluation

The trainee should be capable of describing to the trainer the types of DNA used for hair comparisons including how nDNA and mtDNA differ.

Chapter 9 Interpretation and Reporting

General Discussion

This module is designed to help the trainee learn how to bring all analytical results together to a logical conclusion. The trainee should look at the circumstances of the incident and consider what information can be contributed to the investigation from the analysis of the hair. The trainee should be reminded that findings must be impartial, informative, useful, and based on the physical evidence and not tailored to support the claims of one party over another.

The trainee will be taught to write reports according to laboratory protocols. Report writing is also discussed in the SWGMAT Forensic Human Hair Examination Guidelines which can be obtained from *Forensic Science Communications*, January 2005, www.FBI.gov.

Objectives

In this module, the trainee will learn how to:

- **Reach scientifically supportable conclusions based upon analytical results**
- **Recognize the significance of relevant evidence with respect to a particular incident**
- **Write reports with appropriate limitations, interpretations, conclusions and statements**

Training Steps

1. Reading Assignments

- **Aitken, C. and Robertson, J., "The Value of Microscopic Features in the Examination of Human Head Hairs, 1: Statistical analysis". In: *The Journal of Forensic Sciences,* 31(2):546-562. 1986.**
- **Bisbing, R., "Hair Comparison: Microscopic". In: Seigel, J., ed. *Encyclopedia of Forensic Sciences*, pp 1002-1016. London: Academic Press Ltd., 2000.**
- **Barnett, P. and Ogle, R., "Probabilities and Human Hair Comparison". In: *The Journal of Forensic Sciences,* volume 27(2):272-278. 1982.**
- **Deedrick, D. and Koch, S., 2004. "Microscopy of Hair Part 1: A Practical Guide and Manual for Human Hairs". In: *Forensic Science Communications*, volume 6, no. 1 accessed at http://www.fbi.gov/hq/lab/fsc/backissu/jan2004/research/2004_01_research01b.htm**
- **Gaudette, B., "Hair: Overview". In: Seigel, J., ed. *Encyclopedia of Forensic Sciences*, pp 999-1002. London: Academic Press Ltd., 2000.**

- **Gaudette, B., "Hair Comparison: Other". In: Seigel, J., ed. *Encyclopedia of Forensic Sciences*, pp 1016-1018. London: Academic Press Ltd., 2000.**
- **Gaudette, B., "Hair Comparison: Significance of Hair Evidence". In: Seigel, J., ed. *Encyclopedia of Forensic Sciences*, pp 1018-1024. London: Academic Press Ltd., 2000.**
- **Gaudette, B., "Hair: Hair Transfer, Persistence and Recovery". In: Seigel, J., ed. *Encyclopedia of Forensic Sciences*, pp 1032-1034. London: Academic Press Ltd., 2000.**
- **Gaudette, B., "Hair: Identification of Human and Animal Hair". In: Seigel, J., ed. *Encyclopedia of Forensic Sciences*, pp 1032-1041. London: Academic Press Ltd., 2000.**
- **Gaudette, B., "A Supplementary Discussion of Probabilities and Human Hair Comparisons". In: *The Journal of Forensic Sciences*, volume 27(2):279-289. 1982.**
- **Gaudette, B. and Tessarola, A., "Secondary Transfer of Human Scalp Hair". In: *The Journal of Forensic Sciences*, volume 32(5):1241-1253. 1987.**
- **Gaudette, B., "Strong Negative Conclusions in Hair Comparisons – A Rare Event". In: *The Canadian Society of Forensic Sciences Journal*, volume 17(1):32-37. 1985.**
- **Gaudette, B. and Keeping, E., "An Attempt at Determining Probabilities in Human Scalp Hair Comparison". In: *The Journal of Forensic Sciences*, volume 19(3):599-606. 1974.**
- **Gaudette, B., "Probabilities and Human Pubic Hair Comparisons". In: *The Journal of Forensic Sciences*, volume 21(3):514-517. 1976.**
- **Gaudette, B., Chairperson, "Preliminary Report — Committee on Forensic Hair Comparison". In: *Crime Laboratory Digest*, volume 12(3):44-49. 1985.**
- **Gaudette, B., "Some Further Thoughts on Probabilities and Human Hair Comparisons". In: *The Journal of Forensic Science*, volume 23(4):758-763. 1978.**
- **Gaudette, B., "Evaluation of Associative Physical Evidence". In: *The Journal of Forensic Science Society*, volume 26(3):163-167. 1986.**
- **Gaudette, B., "The Use of Statistics in Forensic Science". In: *The Journal of Forensic Science Society*, volume 27(2):117-118. 1987.**
- **Gaudette, B., "Evidential Value of Human Hair Examination". In Robertson, J., *Forensic and Microscopic Examination of Human Hair,* pp 243-260. London: Taylor and Francis. 1999.**
- **Gaudette, B., "The Future of Forensic Hair Comparison". From: *The Proceedings of the International Symposium on Forensic Hair Comparison*, pages 127-136. Washington, DC: Federal Bureau of Investigation, U.S. Government Printing Office. 1987.**
- **Mann, M., "Hair Transfers in Sexual Assault: A Six Year Case Study". In: *The Journal of Forensic Sciences,* volume 35(4):951-955. 1990.**
- **Wickenheiser, R. and Hepworth, D., "Further Evaluation of Probabilities in Scalp Hair Comparison". In: *The Journal of Forensic Sciences*, volume 35(6):1323-1329. 1990.**

2. Discussion

The trainer and trainee should discuss how to determine what type of analysis is appropriate in a given case, based upon the circumstances of the incident. For example in an assault, finding victim's hairs with telogen roots on the clothing of a defendant may not be significant if the victim and defendant lived together. However, finding a clump of victim's hairs with anagen roots on the clothing of this defendant may be meaningful. Context is essential in defining the problem being addressed scientifically.

The trainer and trainee should also discuss and understand the conclusions from a hair comparison. The trainer and trainee should discuss and understand how the meanings and limitations of conclusions from a hair comparison differ; e.g. similarity, dissimilarity, and inconclusive. The trainer and trainee should discuss factors that affect the strengths and weaknesses of an association.

The trainer and trainee should discuss and understand the difference and significance between Type I and Type II errors in hair comparisons.

3. Practical Exercises

The trainee should be tasked with writing short essays on human hair comparisons for various scenarios which describe in detail the conclusions and interpretation, including how testimony would be given. The trainer should review and discuss the essays with the trainee.

The trainee should also be tasked with writing reports on simulated hair cases according to laboratory guidelines.

4. Competency Evaluation

The trainee's knowledge and competency with regard to performing an analysis, recovering and recognizing questioned hairs, making comparisons, reaching conclusions, and preparing reports should be evaluated by the trainer.

Chapter 10 Moot Court and Competency Examination

General Discussion

This module will give the trainee knowledge of courtroom policies and procedures. The trainee will be made aware of the importance of a pretrial conference with the attorney. The trainee should be made aware of the legal and ethical obligations as an expert witness. The weight that hair evidence carries in court is influenced by the testimony given by the analyst. Each analyst should be careful when explaining a hair examination and comparison, and the final results. The limitations of the microscopic examination should be explained, but, at the same time, the importance of the association or exclusion should also be stressed. This module should include observation of the testimony of a senior analyst and practice by the trainee in a simulated courtroom situation. The trainee should understand the laboratory procedures regarding the monitoring of courtroom testimony.

Objectives

In this module, the trainee will gain knowledge in:

- **Courtroom policies and procedures**
- **Participating in pretrial conferences**
- **The presentation of hair examination results in court**
- **The legal and ethical obligations of an expert witness**
- **Admissibility issues regarding hair evidence**

Training Steps

1. Reading Assignments

- **Deedrick, D. and Koch, S., 2004. "Microscopy of Hair Part 1: A Practical Guide and Manual for Human Hairs". In: *Forensic Science Communications*, volume 6, no. 1 accessed at http://www.fbi.gov/hq/lab/fsc/backissu/jan2004/research/2004_01_research01b.htm**
- **Houck, M., Bisbing, R., Watkins, T. and Harmon, R., 2004. "Locard Exchange: The Science of Forensic Hair Comparisons and the Admissibility of Hair Comparison Evidence: Frye and Daubert Considered". In: *Modern Microscopy Journal accessed at* http://www.modernmicroscopy.com/main.asp?article=36**
- **Houck, M., 1999. "Statistics and Trace Evidence: The Tyranny of Numbers". In: *Forensic Science Communications,* volume 1, no. 3 accessed at http://www.fbi.gov/hq/lab/fsc/backissu/oct1999/houck.htm**

2. Practical Exercises

The trainee should review transcripts of hair testimonies and if possible, examples of exemplary and problematic hair testimony. From these transcripts, the trainee should critique the testimony given and formulate answers to the direct and cross examination questions asked by the attorneys. The trainer and the trainee should review and discuss both the original testimony and the trainee's answers. The trainee should be given exercises where his or her own questions are formulated and the trainee participates in explaining to the presenting attorney the results of the hair examination. The trainee should participate in practice moot courts and be evaluated by the trainer.

3. Observation

The trainee should observe the pretrial conference and testimony of senior hair examiners. Afterward, the trainer and trainee should discuss the various aspects of testifying:

- **Appearance and demeanor**
- **Presenting credentials in a voir dire**
- **Addressing chain of custody issues**
- **Jury education on hair evidence**
- **Presenting results accurately in layman's terms**
- **Cross-examination**
- **Jury's reaction**

4. Competency Evaluation

The trainee should be given a competency test as required by the laboratory. The test should be a comprehensive test encompassing the entire process of hair examination. Upon successful completion of the competency test, the trainee should be subjected to a moot court, staged as realistically as possible. The trainee's performance should be critiqued with the goal of helping the trainee improve in the future. Special attention should be given to the trainee's appearance, demeanor, knowledge, and ability to present the results in an understandable manner to the jury.