



# Standard Practice for Training in the Forensic Examination of Hair by Microscopy<sup>1</sup>

This standard is issued under the fixed designation E3175; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon ( $\epsilon$ ) indicates an editorial change since the last revision or reapproval.

## 1. Scope

1.1 This practice covers training guidelines for use by forensic laboratory personnel responsible for training forensic examiners that will perform hair examinations, including microscopical comparisons of human hair.

1.2 Forensic hair examiners are trained in accordance with Practice E2917 and the discipline-specific guidelines (Guide E3316) and criteria within this practice.

1.3 This practice contains guidelines that include the tasks, goals, and objectives that allow the trainee to acquire the requisite knowledge, skills, and abilities to independently perform casework in the microscopical examination of hair.

1.4 This practice addresses the correlation between the analytical results of microscopical examinations and the potential for DNA analysis.

1.5 This practice addresses training for the microscopical examination of hairs and not the examination of chemical alterations (for example, hair dye) or trace materials on the surface of hairs (for example, hair care products).

1.6 *This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety, health, and environmental practices and determine the applicability of regulatory limitations prior to use.*

1.7 *This international standard was developed in accordance with internationally recognized principles on standardization established in the Decision on Principles for the Development of International Standards, Guides and Recommendations issued by the World Trade Organization Technical Barriers to Trade (TBT) Committee.*

## 2. Referenced Documents

### 2.1 ASTM Standards:<sup>2</sup>

E620 Practice for Reporting Opinions of Scientific or Technical Experts

E1459 Guide for Physical Evidence Labeling and Related Documentation

E1492 Practice for Receiving, Documenting, Storing, and Retrieving Evidence in a Forensic Science Laboratory

E1732 Terminology Relating to Forensic Science

E2917 Practice for Forensic Science Practitioner Training, Continuing Education, and Professional Development Programs

E3316 Guide for Forensic Examination of Hair by Microscopy

## 3. Terminology

3.1 *Definitions*—For definitions of terms used in this practice, refer to Terminology E1732.

### 3.2 *Definitions of Terms Specific to This Standard:*

3.2.1 *anagen, n*—the active growth phase of a hair follicle in the hair growth cycle.

3.2.1.1 *Discussion*—The root from a pulled anagen hair is elongated and is usually fully pigmented.

3.2.2 *ancestral group, n*—a biogeographic designation of human populations (for example, Asian, African, European) whose hair can share similar morphological and microscopic traits.

3.2.2.1 *Discussion*—The racial terms Caucasoid, Mongoloid, and Negroid should not be used as these terms are no longer acceptable in the field of anthropology (the field from which these designations originated).

3.2.3 *association, inclusion, n*—the result of a comparison between two hair samples in which the characteristics of the questioned hair are present in the known hair sample without any exclusionary differences and, therefore, the donor of the known sample can be included as a possible source of the questioned hair.

3.2.3.1 *Discussion*—A microscopical association of hair cannot identify the definitive source of a questioned hair to the exclusion of all others and the number of individuals who could be included as a possible donor of a specific hair is unknown and cannot be reliably estimated.

3.2.4 *buckling, n*—an abrupt change in the shape and orientation of a hair shaft with or without a slight twist.

3.2.5 *catagen, n*—the transitional phase of the hair follicle between the active growth phase (anagen) and the resting phase (telogen) in the hair growth cycle.

<sup>1</sup> This practice is under the jurisdiction of ASTM Committee E30 on Forensic Sciences and is the direct responsibility of Subcommittee E30.01 on Criminalistics. Current edition approved Nov. 1, 2022. Published January 2023. DOI: 10.1520/E3175-22.

<sup>2</sup> For referenced ASTM standards, visit the ASTM website, [www.astm.org](http://www.astm.org), or contact ASTM Customer Service at [service@astm.org](mailto:service@astm.org). For *Annual Book of ASTM Standards* volume information, refer to the standard's Document Summary page on the ASTM website.

3.2.6 *classification, n*—the systematic arrangement of hairs into categories (for example, human, animal, somatic origin, ancestry) based on shared traits.

3.2.7 *cortex, n*—the primary anatomical region of a hair between the cuticle region and the medullary region composed of elongated and fusiform cells.

3.2.8 *cortical fusi, n*—small air spaces that form between the cortical cells in the hair shaft and, under transmitted light, appear as tiny, dark structures.

3.2.9 *cortical texture, n*—the relief or definition of the margins of the cortical cells when viewed using transmitted light microscopy.

3.2.10 *cross-sectional shape, n*—the shape of a hair shaft when cut at a right angle to its longitudinal axis.

3.2.10.1 *Discussion*—When viewed longitudinally with transmitted light, the apparent cross-sectional shape is determined by slowly focusing through the hair (optical cross-sectioning). When viewed longitudinally between crossed polars, the cross-sectional shape can be determined by observing the interference colors.

3.2.11 *cuticle, n*—the outermost region of a hair composed of layers of overlapping scales.

3.2.11.1 *Discussion*—The dimension of the cuticle as measured from its outer margin to the cortex is often described in relative terms (for example, thin, medium, thick).

3.2.12 *cuticle, cracked, n*—a cuticle with linear breaks that are perpendicular to the length of the shaft.

3.2.13 *cuticle, looped, n*—a feature in which the distal edges of the cuticular scales are curved away from or cupped toward the hair shaft.

3.2.14 *cuticle, serrated, n*—a cuticle in which the outer margin has a notched appearance like a saw blade.

3.2.15 *decompositional changes, n*—alteration in the root or the proximal end of a hair that can include discoloration, postmortem root banding, or a tapered or brush-like appearance, as well as fungal tunneling along the length of the shaft.

3.2.16 *distal end, n*—the end of the hair farthest away from the root.

3.2.17 *exclusion/elimination, n*—the result of a comparison between two hair samples in which exclusionary differences are observed in the characteristics of the questioned hair that are not present in the known hair sample, and therefore the donor of the known sample can be excluded as a possible source of the questioned hair.

3.2.17.1 *Discussion*—This result is reached in a comparative hair examination when exclusionary differences (for example, color, characteristics indicative of ancestry) are noted in the macroscopic or microscopic characteristics between the questioned and known hairs. In these circumstances, the source of the known hairs, as represented by the known sample, is eliminated as a possible source of the questioned hair.

3.2.18 *exclusion with limitations, n*—the result of a comparison between two hair samples in which the characteristics of the questioned hair differ from those present in the known

hair sample, and therefore the donor of the known sample cannot be included as a possible source of the questioned hair.

3.2.18.1 *Discussion*—This result is reached in a comparative hair examination when differences are noted in the macroscopic or microscopic characteristics between the questioned and known hairs; however, the differences are insufficient for an absolute exclusion of a person as a possible source. This could be due to the natural variation that occurs in hairs as a biological specimen, the effect that time or environment can have upon a hair, or the reference sample does not capture the complete variation of the individual's hair.

3.2.19 *exclusionary difference, n*—a difference in a feature or property between compared items that is substantial enough to determine that they did not originate from the same source.

3.2.20 *fungal tunneling, n*—air pockets in a hair shaft caused by fungal growth.

3.2.21 *hair, n*—a fibrous outgrowth from the skin of mammals.

3.2.22 *hair follicle, n*—an invagination of the epidermis which contains the root of the hair.

3.2.23 *imbricate, n*—a term that describes a scale pattern in which the scales overlap and the edges have an irregular wavy pattern. This pattern is typical of human hair.

3.2.24 *inconclusive, n*—the result of a comparison between two hair samples in which similarities and differences were observed in the characteristics of the provided standard and the questioned hair to the extent that the known source of the standard could not be included or excluded as a possible source of the questioned hair.

3.2.25 *individualization, n*—a term indicating an individual can be discriminated to the exclusion of all other sources.

3.2.25.1 *Discussion*—Hairs cannot be individualized via microscopical hair comparison.

3.2.26 *inner cuticle margin, n*—the border between the cortex and the visible cuticle.

3.2.27 *keratin, n*—a class of sulfur-containing fibrous proteins that forms the foundation of outgrowth tissue from the epidermis, such as hair, nails, feathers, and horns.

3.2.28 *macroscopic, n*—a term that describes characteristics large enough to be perceived without magnification.

3.2.29 *medulla, n*—the core of the hair shaft that is composed of vacuoles and cells that can be air- or fluid-filled.

3.2.29.1 *Discussion*—The medulla (if present) occurs in a continuous, discontinuous, or fragmented pattern along the length of a hair and appears translucent or opaque.

3.2.30 *microscopic, n*—a term that describes characteristics too small to be resolved by the unaided eye, but large enough to be resolved with a microscope.

3.2.31 *microscopical, n*—concerning a microscope or the use of a microscope.

3.2.32 *monilethrix, n*—a hair disorder that results in periodic nodes or beading along the length of the hair with intervening, tapering constrictions that are not medullated.

3.2.33 *ovoid bodies, n*—oval-shaped, heavily-pigmented inclusions usually found in the hair cortex.

3.2.34 *pigment aggregation, n*—clusters of pigment granules.

3.2.35 *pigment density, n*—the relative abundance of pigment granules in the hair cortex as described along a continuum (for example, sparse, medium, heavy).

3.2.36 *pigment distribution, n*—the pattern or arrangement of the pigment granules in the hair shaft, such as uniform, peripheral, one-sided, variable, or central.

3.2.37 *pigment granules, n*—small particles in hair composed of melanin that impart color.

3.2.37.1 *Discussion*—Melanin is a natural pigment of which two forms, eumelanin (brown to black) and pheomelanin (reddish brown to yellow), determine the color of human and animal hair.

3.2.38 *pili annulati, n*—a hair disorder causing hairs to appear ringed or banded due to the alternating light and dark bands in the hair shaft. The dark bands are a manifestation of abnormal air spaces in the cortex.

3.2.39 *pili torti, n*—a hair disorder characterized by the hair shaft being flattened and twisted 180 degrees numerous times along its axis. It is usually found at irregular intervals along the shaft.

3.2.40 *postmortem root banding, n*—the appearance of an opaque band near the root/proximal end of a hair potentially observed in anagen or catagen hairs that have been removed from a decomposing body. The possibility of other conditions causing the same or similar characteristics cannot be eliminated.

3.2.41 *proximal end, n*—the portion of the hair closest to, and including, the root.

3.2.42 *root, n*—the structure that anchors a hair to a follicle and from which cells divide and produce the hair shaft.

3.2.42.1 *Discussion*—The portion of follicular tissue surrounding a root structure is the sheath.

3.2.43 *sample, known, n*—a sample for which the identity of the donor is established and which is used for comparison purposes.

3.2.44 *sample, limited, n*—a sample of known hairs that is insufficient in quality or quantity to reflect a representative range of characteristics or traits.

3.2.45 *sample, representative, n*—a collection of hairs from a specific somatic region that reflects the range of characteristics in a person's hair in that area.

3.2.46 *scales, n*—overlapping, plate-like structures composed of keratin that form the cuticle.

3.2.47 *shaft, n*—the portion of the hair emerging from the hair follicle.

3.2.48 *shaft form, n*—the shape of the hair both longitudinally (for example, curly, straight) and cross-sectionally (for example, round, flattened).

3.2.49 *shaft thickness, n*—the diameter of the hair.

3.2.49.1 *Discussion*—This is expressed either numerically or in relative terms, such as fine, medium, or coarse.

3.2.50 *shouldering, n*—a variation of the hair form along the shaft, resulting in an irregular and often asymmetrical change of cross-sectional shape.

3.2.51 *somatic region, n*—an area of the body, such as head, pubic, or leg; synonymous with “body area”.

3.2.52 *telogen, n*—the resting phase of the hair follicle in the hair growth cycle.

3.2.52.1 *Discussion*—During this phase, the hair has stopped growing and the root becomes keratinized and bulbous (club-like) in shape.

3.2.53 *tip, n*—the most distal end of a hair shaft.

#### 4. Significance and Use

4.1 A training program provides the theoretical foundation and practical skills necessary for a trainee to become a qualified forensic hair examiner.

4.2 A trainee is directly supervised by a qualified examiner throughout their training. At the end of the training program, a successful trainee is capable of forming opinions, presenting and explaining evidence, and understanding the limitations of analytical results and interpretations based upon sound scientific knowledge, validated procedures, and practical experience.

4.3 A trainee is required to meet the minimum training criteria in Practice E2917 and this practice. It is the laboratory management's responsibility to ensure the selected trainee has the appropriate educational background. It is recommended that, at a minimum, the trainee possess a bachelor's degree in a natural science.

4.4 This document outlines lessons, practical exercises, and criteria to monitor and evaluate trainee progress and is designed to be incorporated into an overall laboratory training program.

4.5 Additional training beyond that which is listed here should be made available to the trainee. Such training might include off-site courses, internships, and specialized training by experienced examiners. Continuing education and training will provide a forensic examiner the opportunity to remain current in the field.

4.6 Additional analyses can be performed on hairs that have been chemically altered (for example, dyed hair) or have trace materials on the surface (for example, glitter). Such techniques are beyond the scope of this document.

4.7 This practice addresses the benefit of following microscopical examinations with DNA analysis.

#### 5. Syllabus

5.1 A training program syllabus and guidelines should contain tasks, goals, and objectives that allow the trainee to acquire the requisite knowledge, skills, and abilities to independently perform casework in the microscopical examination of hair. It should include different types of instruction and learning (for example, classroom-like instruction, practical

exercises, self-study of relevant literature) with progress continually assessed through oral and written evaluations, including pass/fail criteria and provisions for remedial training. This can be accomplished through a combination of the following types of training:

- 5.1.1 Reading of relevant literature.
- 5.1.2 Instruction and observation of hair examiners:
  - 5.1.2.1 Lectures and discussions,
  - 5.1.2.2 Practical demonstration of basic skills,
  - 5.1.2.3 Supervised casework, and
  - 5.1.2.4 Monitored court testimony.
- 5.1.3 Practical skills:
  - 5.1.3.1 Practical exercises, and
  - 5.1.3.2 Assisting in and performing supervised casework.
- 5.1.4 Examinations and tests:
  - 5.1.4.1 Written or oral tests,
  - 5.1.4.2 Practical laboratory tests, and
  - 5.1.4.3 Mock/moot court.
- 5.1.5 Competency evaluation in accordance with Practice

#### E2917.

5.2 This is an extensive training program and it is expected that it will take approximately six months to one year to complete.

- 5.2.1 Required topics include:
  - 5.2.1.1 Occurrence, transfer, and persistence of hairs,
  - 5.2.1.2 Evidence recovery methods,
  - 5.2.1.3 Evidence handling to minimize contamination and loss,
  - 5.2.1.4 Evidence packaging and documentation,
  - 5.2.1.5 Use and maintenance of microscopes,
  - 5.2.1.6 Understanding of hair chemistry, biology, structure, and function,
  - 5.2.1.7 Recognition of roots in different growth stages,
  - 5.2.1.8 Recognition of diseases manifested in hairs (for example, monilethrix, pili annulati, pili torti),
  - 5.2.1.9 Recognition of characteristics indicative of mechanical damage (for example, looped or serrated cuticle), environmental effects, decomposition (for example, postmortem root band), and chemical treatments (for example, cortical texture, dye lines),
  - 5.2.1.10 Identification and classification of hairs,
  - 5.2.1.11 Comparison of questioned and known hairs,
  - 5.2.1.12 Other analytical techniques (DNA),
  - 5.2.1.13 Interpretation of comparison results, including limitations,
  - 5.2.1.14 Preparation of laboratory reports, and
  - 5.2.1.15 Presentation and interpretation of analytical results in court.

5.2.2 A trainee with experience in other areas of forensic science who has knowledge in microscopy, in other areas of trace evidence, or in court testimony would not require such an extensive training regimen.

## 6. Records of Training

6.1 The training progress is reviewed, assessed, and documented by the trainer(s) in accordance with Practice E2917.

6.2 Training documentation is maintained according to Practice E2917.

## 7. Responsibilities

7.1 Each trainee is trained by, and works under the supervision of, one or more experienced forensic hair examiners.

7.2 Only technically-competent personnel are designated trainers; this would include expertise in the areas of microscopical hair examination, hair comparison, or evaluation of hairs for DNA suitability. These trainers are responsible for:

- 7.2.1 Introducing the trainee to the relevant scientific literature, validated procedures, training material, and reference collections,
- 7.2.2 Discussing readings and theory with the trainee,
- 7.2.3 Teaching basic microscopy methods and techniques for hair microstructure comparison,
- 7.2.4 Teaching case management,
- 7.2.5 Fostering ethical and professional conduct through discussion and by setting an example,
- 7.2.6 Teaching quality assurance and quality control procedures,
- 7.2.7 Reviewing tests, practical exercises, and casework samples with the trainee, and
- 7.2.8 Teaching expert testimony skills through moot court, observation of testimony, or both.

7.3 The trainer and supervisor regularly monitor the trainee's progress with frequent updates.

7.4 The trainee completes the objectives set forth in the training program by:

- 7.4.1 Self-study of reading materials,
- 7.4.2 Practicing basic microscopy skills,
- 7.4.3 Successfully completing practical exercises,
- 7.4.4 Successfully completing written or oral tests, or both,
- 7.4.5 Observing casework being conducted by an experienced examiner,
- 7.4.6 Observing court testimony given by an experienced examiner or reviewing transcripts where hair evidence was presented, or both,
- 7.4.7 Conducting themselves in an ethical and professional manner,
- 7.4.8 Participating in the quality assurance and quality control program of their laboratory,
- 7.4.9 Successfully completing competency tests in identification, comparison, or evaluation for DNA suitability, and
- 7.4.10 Demonstrating competency in supervised casework.

7.5 Each laboratory is responsible for maintaining:

- 7.5.1 An up-to-date training program, and
- 7.5.2 Documentation of training, including competency tests.

## 8. Training Program Requirements

8.1 The following sections outline the minimum requirements for a training program by topic area. A laboratory may modify the training program to correspond with specific areas of hair examination performed in their laboratory.

8.1.1 Each topic area is divided into sections that include general discussions of the subject in that particular topic area; the skill 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.

8.1.2 Reading assignments are selected to give the trainee a sound theoretical background and solid foundation in topics necessary for hair examination. The listed publications can be supplemented by additional readings.

8.1.3 Essential skills are demonstrated by the trainer and practiced by the trainee.

8.1.4 Practical exercises are designed to provide the trainee the skills necessary to perform casework. The trainer observes the trainee's performance during the exercises and evaluates the trainee's ability to conduct microscopical examinations. The trainer will document the assessment and make a determination about the need for additional training. Satisfactory completion of the exercises is documented.

8.1.5 To assess the trainee's comprehension of the materials, use a combination of written, oral, and practical laboratory tests. The trainer should address deficiencies through additional training.

8.1.6 The trainee observes an experienced hair examiner perform 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; and the characterization, identification, comparison, and interpretation (including the limitations) of hair evidence. During the observation of casework, the experienced examiner provides instruction to the trainee while performing all examinations and comparisons. The examiner also demonstrates the documentation of observations and reporting of analytical results and interpretations.

8.1.7 A competency test is administered prior to the trainee analyzing and comparing hair evidence in supervised casework.

8.1.7.1 *Discussion*—The test should be designed to mimic actual casework, requiring the trainee to demonstrate knowledge of the laboratory's procedures in handling evidence, taking notes, maintaining chain of custody, and writing a report, as well as the actual examination and comparisons of hair evidence. It is the responsibility of the laboratory management to establish written objective criteria for successfully passing the competency test. Deficiencies or failures, if any, are noted, a remediation plan developed, and a subsequent competency exam given until the trainee meets the criteria for successfully passing the competency exam.

8.1.8 Prior to independent casework, the trainee performs supervised casework. The trainer or case supervisor verifies all laboratory results obtained by the trainee and documents that verification during supervised casework.

8.1.9 The trainee should observe experienced examiners testifying in court. 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 the examiner should discuss the courtroom experience and, if possible, review the transcript.

8.1.10 Court testimony training includes a moot court exercise. The trainee's moot court is challenging and mimics as

closely as possible a real courtroom experience. The trainee is evaluated on appearance, demeanor, knowledge of the case, knowledge of the discipline, scientific accuracy, impartiality, and presentation skills.

8.1.11 The trainee's progress is 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 are addressed immediately. Remediation should be made available through additional training and a re-evaluation of the training program.

8.1.12 Continued deficiencies could suggest the unsuitability of the trainee for casework in this area.

### 8.2 *Training Course Evaluation:*

8.2.1 Evaluate the training program to assess its efficacy and relevance as described in Practice E2917.

8.2.2 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.

### 8.3 *Authorization for Casework:*

8.3.1 Upon successful completion of the training program and a comprehensive competency test, the trainee will receive written approval from designated laboratory personnel (for example, quality control officer, training manager) to perform supervised casework.

8.3.2 After successful completion of supervised casework, the trainee will receive written approval from designated laboratory personnel (for example, quality control officer, training manager) to perform independent casework in microscopical hair examinations.

## 9. Casework Familiarization, Search, and Recovery of Hair Evidence

9.1 This section familiarizes the trainee with the documentation needed in casework and the methods of detection, collection, and preservation of trace evidence from crime scenes and from items submitted to the laboratory. This training exposes the trainee to evidence handling issues such as deposition, transfer, persistence, contamination, and loss of trace evidence.

9.2 Expose the trainee to a variety of cases involving hair examinations throughout the training period.

### 9.3 *Required Training Topics Include:*

9.3.1 Procedures for case documentation,

9.3.2 Recognition of hair and other evidentiary materials and the evaluation of their significance in a particular case,

9.3.3 Detection, collection, and preservation techniques appropriate to the different types of forensic evidence, including hairs,

9.3.4 Loss, transfer, and persistence of trace evidence,

9.3.5 Prevention of contamination and loss in handling hair evidence,

9.3.6 Laboratory procedures for maintaining the chain of custody of the original evidence and secondary evidence collected,

9.3.7 Safety procedures in the laboratory for the handling of potentially biohazardous materials, and

9.3.8 Documentation of analytical results, as required by the trainee's laboratory.

9.4 Review relevant historical and current literature in the fields of anthropology, dermatology, cosmetology, developmental biology, and forensic science related to hair examinations.

9.4.1 *Recommended Reading Assignments:*

(1) ASTM Standards:<sup>2</sup>

(a) **E1459**, Guide for Physical Evidence Labeling and Related Documentation

(b) **E1492**, Practice for Receiving, Documenting, Storing, and Retrieving Evidence in a Forensic Science Laboratory

(2) Bisbing, R., "The Forensic Identification and Association of Human Hair," In: Saferstein, R. (Ed.), *The Forensic Science Handbook*, Vol 1, 2<sup>nd</sup> edition, Upper Saddle River, New Jersey: Pearson Education, 2002, pp. 390-428.

(3) Inman, K., and Rudin, N., *Principles and Practice of Criminalistics, the Profession of Forensic Science* (Chapters 4, 5, 9, and 10), Boca Raton: CRC Press, 2001.

(4) Oien, C.T., "Forensic Hair Comparison: Background Information for Interpretation," *Forensic Science Communications*, Vol 11, No. 2, 2009.

(5) Robertson, J., "Forensic and Microscopic Examination of Human Hair." In: J. Robertson (Ed.), *Forensic Examination of Hair*, London: Taylor and Francis, 1999, pp. 79-155.

(6) Robertson, J., and Roux, C., "From the Crime Scene to the Laboratory—Transfer, Persistence and Recovery of Fibres," In: Robertson, J. and Grieve, M. (Eds.), *Forensic Examination of Fibres*, 2<sup>nd</sup> edition, London: Taylor and Francis, 1999, pp. 89-100.

(7) Springer F., "From the Crime Scene to the Laboratory – Collection of Fibre Evidence from Crime Scenes," In: Robertson, J. and Grieve, M. (Eds.), *Forensic Examination of Fibres*, 2<sup>nd</sup> edition, London: Taylor and Francis, 1999, pp. 101-115.

9.5 *Instruction and Observation:*

9.5.1 Observe hair casework, from the assignment of a case through an examination, to the preparation of a report.

9.5.2 Discuss all aspects of casework, having the trainer explain each step as the case is processed.

9.5.3 Instruction will be given in the following topics:

9.5.3.1 Documentation required for a case file,

9.5.3.2 Description and labeling of evidence,

9.5.3.3 Procedures required to maintain chain of custody,

9.5.3.4 Procedures to prevent contamination and loss,

9.5.3.5 Procedures to clean and control the laboratory environment,

9.5.3.6 Selection of the appropriate detection, collection, and preservation techniques for hair and other trace evidence,

9.5.3.7 Recognition of evidence as questioned specimens or known samples,

9.5.3.8 Collection of representative known samples,

9.5.3.9 General laboratory protocols,

9.5.3.10 Health and safety hazards, and

9.5.3.11 Laboratory quality assurance procedures.

9.6 *Practical Exercises:*

9.6.1 Practice collecting hair from a variety of items (for example, clothing, tape, items of various sizes and surface textures, weapons). Skills practiced should include:

9.6.1.1 Different techniques of recovery (for example, scraping, tape lifting, vacuuming, picking),

9.6.1.2 Packaging and preserving evidence, and

9.6.1.3 Collection of known or reference materials on mock evidence.

9.7 *Supervised Casework:*

9.7.1 Under the direct supervision of the trainer, the trainee is assigned select cases to process for the purposes of recovering and safeguarding trace materials. The trainee will use the procedures and techniques learned to process and document the evidence.

9.8 *Examinations and Tests:*

9.8.1 Written, oral, or practical laboratory tests, or any combination thereof, are given to the trainee to evaluate the acquired knowledge and skills covered in each part of training.

9.9 *Competency Evaluation:*

9.9.1 Evaluate the trainee's ability to choose and perform an appropriate evidence recovery technique.

9.9.2 Evaluate the trainee's knowledge of laboratory procedures for creating a case file, handling evidence safely, and labeling evidence.

## 10. Microscopy

10.1 This section familiarizes the trainee with the theory, basic procedures, and techniques for the operation of a stereomicroscope, compound microscope, and comparison microscope. The care and maintenance of these microscopes should also be discussed.

10.2 *Required Training Topics Include:*

10.2.1 Why different types of microscopes are used in hair examination,

10.2.2 How microscopes work (theory),

10.2.3 The operation and maintenance of the different types of microscopes,

10.2.4 Setting up Köhler (or modified Köhler) illumination, and

10.2.5 The selection of mounting media.

10.3 *Recommended Reading Assignments:*

(1) Operation manuals for the microscopes used by the trainee.

(2) Collins, T., "Mounting Media and Antifade Reagents," *Microscopy Today*, Vol 14, No. 1, 2006, pp. 34-39.

(3) De Forest, P.R., "Foundations of Forensic Microscopy." In: Saferstein, R. (Ed.), *The Forensic Science Handbook*, 2<sup>nd</sup> edition, Upper Saddle River, New Jersey: Pearson Education, 2002, pp 215-320.

(4) Greenwell, M.D., Willner, A., and Kirk, P., "Human Hair Studies: III. Refractive Index of Crown Hair," *J Criminal Law and Criminology*, Vol 31, No. 6, 1941, pp. 746-752.

(5) Neuhaus, B., and Schmid, T., "Collection Management and Study of Microscope Slides: Storage, Profiling, Deterioration, Restoration Procedures and General Recommendations," *Zootaxa*, Vol 4322, No. 1, 2017, pp.1-173.