



<b>ATF LS Examination, Analysis and Comparison of Hair Evidence</b>	Published Online: <b>March 2018</b>
Authority: Technical Leader	
Unofficial Copy; May Not Be Most Current Version	Page: 1 of 12

## I. SCOPE

Many different crimes involve the recovery of trace evidence from articles of clothing, vehicles, crime scenes, or other items, which may contain hairs. The forensic hair examiner may be requested to analyze a questioned sample in an attempt to determine if something is indeed a hair and if it is from an animal or a human being. If the hair is from an animal, species identification may be attempted. If from a human, the somatic origin (body area) of the hair may be determined by general morphology. A human hair may also be associated to a particular racial group based on established models for each group. Forensic hair examiners differentiate between hairs of Caucasoid or Caucasian (European ancestry), Mongoloid (Asian ancestry), and Negroid (African ancestry) origin, all of which exhibit microscopic characteristics that distinguish one racial group from another. Also, hairs may be evaluated to determine if further microscopical and/or DNA comparisons may be conducted.

In many instances, the forensic hair examiner may be requested to compare questioned and known (Q and K) hair samples based on their physical appearance. The purpose for conducting a hair comparison is to ascertain whether two or more individuals could have come into contact with one another, or whether one or more individuals may have come into contact with (or are associated with) a particular item or location. If known and questioned hair samples are determined to possess the same microscopic characteristics, it may be concluded that the known and questioned hairs could have, or are consistent with having come from the same individual.

## II. REFERENCES

1. Scientific Working Group for Materials Analysis, Forensic Hair Examination Guidelines, [http://www.asteetrace.org/WebPages.cfm?action=viewCat&BIZ\\_UNL\\_id=41614](http://www.asteetrace.org/WebPages.cfm?action=viewCat&BIZ_UNL_id=41614)
2. ASTM Standard E 1459-92 Standard Guide for Physical Evidence Labeling and Related Documentation.
3. ASTM Standard E1492-92 Standard Practice for Receiving, Documenting, Storing and retrieving Evidence in a Forensic Science Laboratory.
4. Forensic Examination of Hair, J Robertson, 1999.
5. Microscopy of Hair Part 1: A Practical Guide and Manual for Human Hairs, D Deedrick and S. Koch, 2003.
6. "Evaluation of the Human Hair Root for DNA Typing Subsequent to Microscopic Comparison" by Linch et al (JFS 1998;43(2):305-314)



<b>ATF LS Examination, Analysis and Comparison of Hair Evidence</b>	Published Online: <b>March 2018</b>
Authority: Technical Leader	
Unofficial Copy; May Not Be Most Current Version	Page: 2 of 12

7. "The Morphology and Evidential Significance of Human Hair" by Petraco et al (J FS1998;33(1): 68-76).
8. Forensic Science Handbook, Volume 1, 2nd Edition, R Saferstein, 2002.
9. Atlas of Human Hair, R Oole Jr. and M Fox, 1999.

### **Validation**

The techniques described below for hair examination are well known and scientifically accepted in the forensic science community and in private industry. Relevant examples of related literature can be found in Section II (References).

### **III. SAFETY PRECAUTIONS**

1. The examiner should follow all the biohazard procedures and use universal safety precautions.
2. Precautions need to be taken whenever working with chemicals which could pose potential health hazards.

### **IV. APPARATUS / REAGENTS**

1. Sticky sided collecting materials such as tape or Post-it Notes
2. Forceps
3. Containers such as glassine envelopes, plastic bags or vials
4. Illuminated Magnifier
5. Transparent securing substrates such as slides or sheet protectors
6. Vacuum, usually with clean filter attachments for collecting hairs.
7. Glass microscope slides
8. Glass cover-slips
9. Mounting medium
10. Stereomicroscope
11. Transmitted Light microscope



<b>ATF LS Examination, Analysis and Comparison of Hair Evidence</b>	Published Online: <b>March 2018</b>
Authority: Technical Leader	
Unofficial Copy; May Not Be Most Current Version	Page: 3 of 12

12. Comparison microscope
13. Miscellaneous laboratory supplies or equipment

## **V. PROCEDURES**

### **A. RECOVERY OF HAIRS**

#### **Purpose:**

Items of evidence are examined for foreign hairs that may be associated with a known source. Document the condition of the submitted items and any recovered hairs that may be used for comparisons with known submitted samples.

#### **Summary:**

Generally speaking, submitting the article or articles of evidence to the laboratory for the examiner to process is the best approach to the recovery of hairs. There are instances where this is not practical or possible, such as recovering hairs from wall-to-wall carpeting, a large piece of furniture, or a vehicle. In these instances, the recovery of hairs may be accomplished at the scene by any of the following methods and submitted for examination.

Hairs may be recovered by manually removing them from an item, or the item may be taped, scraped, or vacuumed in an effort to remove hairs of interest.

Multi-layered tape recovered directly from devices needs to be separated layer by layer and examined for any hairs in protected areas or other evidence that could have originated from the environment in which the item was manufactured. This may be done by the latent print examiner, the explosives chemist, or the trace evidence examiner. Hairs found in the protected areas of the tape are removed with clean forceps.

#### **Minimum Standards and Controls:**

1. The examiner must clean the examination area and change the examination paper between victim and suspect or scene exhibits.
2. The examiner must change gloves and clean their tools between examining the evidence from different individuals or locations. Use separate laboratory coats during the collection of the known and questioned items.
3. If possible, items from different individuals and different locations should be examined in separate rooms. If this is not possible, then the separation of these items in time and/or space will be



<b>ATF LS Examination, Analysis and Comparison of Hair Evidence</b>	Published Online: <b>March 2018</b>
Authority: Technical Leader	
Unofficial Copy; May Not Be Most Current Version	Page: 4 of 12

necessary. At no time should questioned items and known items be open at the same time in the same area.

#### **Analytical Procedure for Recovery of Hairs:**

1. Clean the examination area. Spread a clean piece of butcher or craft paper out on the examination surface.
2. Examine each item of evidence visually or with the aid of an illuminated magnifier, or low powered microscope.
3. If the item being examined contains hairs that are readily visible, collect them. As hairs are collected, they should be secured and/or preserved in an appropriate manner.
4. Care should be taken to avoid the loss of any hairs, especially when repositioning bulky items.
5. Adhesive tapes and/or other adhesive devices (e.g. "Post-it Notes", lint rollers, etc) may be used to recover hairs. The adhesive surface is placed on the item being examined and then pulled away. The tape may then be placed on a clean sheet of plastic (e.g. sheet protector) for further examination and storage.
6. Other collection methods may be used including vacuuming and scraping. If scraping is necessary, the item to be examined is suspended above the examination surface and very gently scraped with a spatula. Scraping in a downward direction allows surface hairs to fall onto the examination surface for collection. If vacuuming is used then separate filters should be used for different areas.
7. When recovering hairs from tape present on submitted items, it is important to remember that exposed areas of the tape may contain environmental (scene) hairs that may be of no probative value, while hairs found under the adhesive may be extremely valuable. Latent print considerations of these tape pieces are paramount as well as other trace evidence (see "Pressure Sensitive Tape Protocol"). Multiple layers of tape should be separated layer by layer for examination. Remove any hairs from the freshly exposed adhesive area(s) and document. The exposed tape adhesive may be placed on a clean non-porous surface for transfer to latent prints.



<b>ATF LS Examination, Analysis and Comparison of Hair Evidence</b>	Published Online: <b>March 2018</b>
Authority: Technical Leader	
Unofficial Copy; May Not Be Most Current Version	Page: 5 of 12

## **B. HAIR EXAMINATIONS AND ANALYSIS**

### **Purpose:**

The purpose of hair examinations and analyses is to identify hairs as to their type (human or animal), identify species or racial characteristics, identify somatic origin, and if suitable for comparison purposes, compare known and questioned samples. Hairs may also be evaluated to determine if they are suitable for nuclear or mitochondrial DNA analysis. When no known hairs are submitted for comparison purposes, the unknown hairs may be characterized and identified only by stereomicroscopy and polarized light microscopy. Comparison microscopy is employed when comparisons are to be conducted between known and unknown hairs.

### **Minimum Standards and Controls:**

A reference collection of hairs may be useful to the examiner when determining if hairs are animal or human, or for identifying species, racial characteristics, or somatic origin.

### **Sampling / Sample Selection:**

Hairs should be first examined using a stereomicroscope. The different physical characteristics may be noted. Hairs may be mounted on glass slides as deemed necessary. When numerous hairs are present in a known or a questioned sample, the examiner will evaluate the hairs on a case by case basis and should attempt to mount up a representative sample of hairs that display the range of variation seen within the sample.

Because groups of questioned hairs cannot be assumed to be from the same individual / body area / animal, sample selection should be utilized when reporting probative microscopical hair examinations. Each hair should be examined independently from all others and results in reports should reflect this.

### **Analytical Procedure for Hair Examination and Analysis:**

Observe the physical properties of the mounted hairs utilizing transmitted light microscope having a magnification range of at least 100X to 400X. When possible, classify the hair as animal or human, identify species or racial characteristics, identify somatic origin, and determine if the hairs are suitable for further comparison (by microscopy and/or DNA) based on the characteristics noted.



<b>ATF LS Examination, Analysis and Comparison of Hair Evidence</b>	Published Online: <b>March 2018</b>
Authority: Technical Leader	
Unofficial Copy; May Not Be Most Current Version	Page: 6 of 12

**The following microscopic characteristics are commonly used to determine if a hair is animal or human:**

**Human:**

1. Medulla is generally amorphous in appearance and the width is generally less than one-third the overall diameter of the hair shaft.
2. Scales are not usually pronounced and the structure is imbricate.
3. Pigment granules are usually distributed toward the cuticle (with the exception of naturally red hair which is often distributed toward the medulla)
4. Generally, the color and pigmentation is consistent throughout the length of the hair shaft.
5. The root is commonly club-shaped.

**Animal:**

1. Medulla is frequently continuous and structured. The width is usually greater than one-third the overall diameter of the hair shaft.
2. Scales are often pronounced, and the structure of the scales can be coronal, spinous, or imbricate.
3. Pigment granules are usually distributed toward the medulla.
4. Radical changes in color along the length of the hair shaft, called banding, is common.
5. The shape of the root is highly variable.

**The following microscopic characteristics are commonly used to determine the racial origin of a human hair:**

**Caucasian or European Ancestry:**

1. Shaft diameter is moderate with minimal variation (mean diameter of human head hairs – 80um)
2. Pigment granules are sparse to moderately dense with fairly even distribution.
3. Cross-sectional shape is oval.



<b>ATF LS Examination, Analysis and Comparison of Hair Evidence</b>	Published Online: <b>March 2018</b>
Authority: Technical Leader	
Unofficial Copy; May Not Be Most Current Version	Page: 7 of 12

**Negroid or African Ancestry:**

1. Shaft diameter is moderate to fine with considerable variation.
2. Pigment granules are densely distributed (hair shaft may be opaque) and arranged in prominent clumps or streaks.
3. Shaft has prominent twist and curl.
4. Cross-sectional shape is flattened.

**Mongoloid or Asian Ancestry:**

1. Shaft diameter is coarse and usually with little or no variation.
2. Pigment granules are densely distributed and often arranged in large patchy areas.
3. Medulla is prominent (often broad and continuous).
4. Cuticle is thick.
5. Cross-sectional shape is round.

**Mixed Racial Hairs:**

1. Hairs exhibiting characteristics common to more than one racial group.

**The following microscopic characteristics are commonly used to determine the somatic origin of a human hair:**

**Head Hairs:**

1. Long with moderate shaft diameter variation.
2. Medulla absent to continuous and relatively narrow when compared to the structure of hairs from other body areas.
3. Often with cut or split ends.
4. Soft texture, pliable.

**Pubic Hairs:**



<b>ATF LS Examination, Analysis and Comparison of Hair Evidence</b>	Published Online: <b>March 2018</b>
Authority: Technical Leader	
Unofficial Copy; May Not Be Most Current Version	Page: 8 of 12

1. Shaft diameter coarse with wide variations and buckling.
2. Medulla relatively broad and usually continuous when present.
3. Root frequently with a follicular tag.
4. Tip usually tapered, rounded, or abraded.
5. Stiff texture, wiry.

#### **Limb Hairs:**

1. Diameter fine with little variation.
2. Gross appearance of hair is arc-like in shape.
3. Medulla is discontinuous to trace with a granular appearance.
4. Tips usually taper and are often blunt and abraded. Scale ends are commonly rounded due to wear.
5. Soft texture.
6. Facial Hairs:
7. Diameter very coarse with irregular or triangular cross-sectional shape.
8. Medulla very broad and continuous may be doubled

#### **Chest Hairs:**

1. Shaft diameter moderate and variable.
2. Tip often darker in color, long and fine, arc-like.
3. Medulla may be granular.
4. Stiff texture.

#### **Axillary or Underarm Hairs:**

1. Resemble pubic hairs in general appearance, but less wiry.



<b>ATF LS Examination, Analysis and Comparison of Hair Evidence</b>	Published Online: <b>March 2018</b>
Authority: Technical Leader	
Unofficial Copy; May Not Be Most Current Version	Page: 9 of 12

2. Medullary appearance similar to limb hairs.
3. Diameter moderate and variable with less buckling than pubic hairs.
4. Tips long and fine, frequently with a bleached appearance.

**Other Hairs:**

1. Eyebrow: Stubby, some diameter fluctuation, saber-like in appearance.
2. Eyelash: Short, stubby with little shaft diameter fluctuation, saber-like in appearance.
3. Trunk: A combination of features of limb and pubic hairs, a transitional hair.

**C. COMPARISON OF QUESTIONED AND KNOWN HAIRS**

**Purpose:**

Questioned and known hairs must be compared using a comparison microscope. It should be noted that only head and pubic hairs from humans possess enough microscopic characteristics to perform a complete comparison. Known and questioned animal hairs may also be compared using a comparison microscope; however animal hairs do not possess enough individual microscopic characteristics to be associated to a particular animal to the exclusion of other similar animals.

**Minimum Standards and Controls:**

1. A comparison microscope must be used when comparing known and questioned hairs.
2. A suitable known hair sample should be used to obtain the best and most reliable results in a hair comparison. A suitable known sample consists of enough hairs (twenty-five pulled hairs and twenty-five combed hairs recovered from various areas of the scalp are optimal) to represent those present on the individuals entire scalp and should consist of complete / full length hairs including the root.

**Sampling / Sample Selection:**



<b>ATF LS Examination, Analysis and Comparison of Hair Evidence</b>	Published Online: <b>March 2018</b>
Authority: Technical Leader	
Unofficial Copy; May Not Be Most Current Version	Page: 10 of 12

Because groups of questioned hairs cannot be assumed to be from the same individual / body area / animal, sample selection should be utilized when reporting probative microscopical hair comparisons. Each hair should be examined independently from all others and results in reports should reflect this.

**Analytical Procedures for Known and Questioned Hair Comparisons:**

1. When comparing hairs, the same analytical techniques should be performed in the same manner on both the known and questioned hairs.
2. If the microscopical characteristics of the known and questioned hairs correspond, a conclusion can be reached that the questioned hair could have originated from / or is consistent with having originated from the donor of the known hair sample.
3. During the hair examination scheme, if any meaningful differences are detected between the questioned and known hairs, a conclusion can be made that the hairs are not consistent with having a mutual origin and no further testing is required.

**C. SCREENING HAIRS FOR DNA ANALYSIS**

**Purpose:**

Recovered hairs may be screened to determine if they are suitable candidates for DNA analysis. If known head or pubic hairs are submitted and meaningful macroscopic/microscopic differences exist between known and unknown hairs, no further analysis may be necessary. If similarities exist, or if hairs from other parts of the body are present, the hairs may then be evaluated for DNA analysis.

**Sampling / Sample Selection:**

When more than one hair is determined to be consistent in microscopic characteristics to a known hair sample, all hairs need not be submitted for DNA analysis. It is left to the discretion of the hair examiner to determine the hairs which are most suitable for DNA analysis. Reports should reflect how many or which hairs were selected for additional DNA examinations.



<b>ATF LS Examination, Analysis and Comparison of Hair Evidence</b>	Published Online: <b>March 2018</b>
Authority: Technical Leader	
Unofficial Copy; May Not Be Most Current Version	Page: 11 of 12

### **Minimum Standards and Controls:**

1. The examiner performing the examination must have sufficient training/ knowledge for human hair screening for DNA analysis.
2. A transmitted light microscope and/or comparison microscope having high magnification range is required.
3. Generally, destructive testing such as DNA analysis is performed after all non-destructive examinations are complete.

### **Analytical Procedures for Screening Hairs for DNA analysis:**

1. Hairs determined to be probative through microscopical comparisons should be examined further microscopically to assess them for future DNA examinations.
2. In cases where no suspect has been identified, hairs may be examined directly for DNA suitability.
3. If significant root tissue is present on the hair in question, or if the hair has an anagen root, it may be suitable for nuclear DNA analysis. If no root tissue is present, hairs may be selected for mitochondrial DNA analysis. As ATF Laboratories do not conduct mitochondrial DNA examinations, these hairs may be sent to the FBI laboratory or to a private laboratory for this type of testing.
4. Hairs selected for DNA analysis should be removed from the glass slides by a hair examiner. If permanently mounted, this may be done by punching a hole in the coverslip using a scribe, placing a drop of xylene or other suitable solvent in the hole to loosen the mounting media, and removing the hair with tweezers. If using a non-permanent mounting media, the coverslip may simply be lifted and the hair removed. The hair should be cleaned in a solvent such as xylene and then with water. The hair may then be placed in a bullet tube with water, or on a post-it note for transfer to the DNA unit. If placed on a post-it note, it is good practice to identify the root end. Photographing the root and measuring the length of the hair prior to DNA analysis is recommended.

## **VI. QUALITY ASSURANCE/ QUALITY CONTROLS**

All probative hair comparisons (e.g. between a suspect and a scene, between a suspect and a victim) which result in a finding that the Q and K hairs are microscopically consistent to one another, must be examined by another qualified examiner (seconded). That examiner must reach an independent opinion as to whether or not the Q and K hairs exhibit the same microscopic characteristics. The results of this examination must be recorded in the notes by the handwritten signature or initials of the seconding examiner. Through proper training, competency testing, and proficiency testing of hair examiners as well as the use of high quality microscopes which are cleaned and maintained appropriately, the quality



<b>ATF LS Examination, Analysis and Comparison of Hair Evidence</b>	Published Online: <b>March 2018</b>
Authority: Technical Leader	
Unofficial Copy; May Not Be Most Current Version	Page: 12 of 12

of this method is maintained. The microscopical examination of hairs does not provide a positive means of personal identification; therefore, the use of error rates is not applicable.