

## Study Guide for the Trace Evidence Examination- Hair and Fiber

### Introduction

Your study guide consists of a Job Description, a list of Knowledge, Skills, and Abilities (KSAs), References, and 10 Sample Question primer for the exam.

- The **Job Description** describes the education, background, training, and specific duties of an analyst in each discipline.
- The **KSAs** have ten major sections. Sections I-IX cover the core knowledge and skills expected of every forensic scientist and comprise 40% of the examination. Section X, consisting of the specific, discipline related, in –depth, upper level knowledge, skills, and abilities will make up 60% of the examination. Please note that the sub-categories listed under the capital letters in the KSAs are examples and are not meant to be all-inclusive, or to indicate that there will necessarily be a question on the exam from every sub-category.
- The **References** are broken into core references and discipline-related references. The core references are identical for all the ABC examinations. The discipline-related references are specific to each discipline.
- There are ten **Sample Questions** to give you an idea of the range of content and difficulty that will appear on the exam. For further information, please see “Introduction to ABC Certification Examinations.”



## Study Guide for the Trace Evidence Examination- Hair and Fiber

### Job Description

A qualified trace (hair and fiber) analyst must be able to:

- Characterize and compare human and animal hairs, through light microscopy.
- Characterize and compare synthetic fibers using microscopy and, when appropriate, chemical and/or instrumental means of analysis.
- Characterize and compare natural fibers using microscopy.
- Characterize and compare textile specimens.
- Characterize and compare cordage specimens.
- Recognize, collect, secure, and preserve physical evidence.
- Recognize the potential for other forensic examinations in areas outside an area of specialization, prioritize the sequence of examinations, and handle evidence accordingly.
- Observe safe practices to insure the safety of analyst and co-workers.
- Engage in impartial and ethical work practices.
- Be proficient in the use and maintenance of laboratory instrumentation.
- Evaluate and interpret results of physical and instrumental analyses.
- Thoroughly and accurately produce documentation to support results and conclusions.
- Testify under oath as to analytical processes, results, and conclusions.
- Recognize and employ quality assurance measures to ensure the integrity of the analyses.



## Study Guide for the Trace Evidence Examination- Hair and Fiber

### Knowledge, Skills, and Abilities

- I. History
  - A. Evolution of practice
  - B. Significant historical figures (e.g., Locard, Gross, Orfila, Kirk)
- II. Crime Scene Preservation
  - A. Securing
  - B. Isolating
  - C. Recording
  - D. Searching
  - E. Recognition of evidentiary value
  - F. Safety
- III. Crime Laboratory Operations-Overview
  - A. Laboratory Disciplines
    - 1. Forensic biology
    - 2. Controlled substances
    - 3. Trace analysis
    - 4. Toxicology
    - 5. Latent fingerprints
    - 6. Questioned documents
    - 7. Fire debris
    - 8. Firearms/Toolmarks
    - 9. Digital evidence
  - B. Evidence associated with each discipline
- IV. QA/QC
  - A. Accreditation, Certification, Standardization
    - 1. Laboratory accreditation
      - a) Audit trails
      - b) Accrediting bodies
      - c) ISO 17025
      - d) FBI Quality Assurance Standards (QAS)
    - 2. Certification of personnel
      - a) ABC
      - b) IAAI
      - c) IAI
      - d) ABFT
      - e) AFTE
      - f) ABFDE
      - g) BFDE
      - h) IACIS

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3. Standardization
  - a) ASTM
  - b) UNODC
  - c) TWG/SWG
  - d) OSAC
  - e) ASB
- B. QA/QC Application
  1. Noncompliant data
  2. Documentation evaluation
  3. Validation and verification
  4. Linearity
  5. Limits of detection
  6. Limits of quantitation
  7. Limits of reporting
  8. Negative and positive controls
  9. Calibrators
  10. Measurement of Uncertainty
  11. Traceability
  12. Corrective and preventative actions
  13. Proficiency testing
  14. Confidence interval/confidence limits
  15. Sampling plans / sample selection
- C. Document/Data Management
  1. Databases
  2. LIMS
  3. Case document preservation/integrity
- V. Safety
  - A. Chemical Hygiene
    1. Safety labeling (SDS)
    2. Globally Harmonized System of Classification and Labeling of Chemicals (GHSCLC)
    3. Communication plans
  - B. Universal Precautions
    1. Bloodborne pathogens
    2. Personal protective equipment
  - C. Hazardous Waste/Biohazardous Waste Handling
    1. Spill control
- VI. Legal
  - A. Decisions/laws
    1. Frye
    2. Daubert/Kumho
    3. Brady
    4. Melendez-Diaz

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- B. Legal terms
  - 1. Chain of custody
  - 2. Discovery
  - 3. Voir dire
- C. Court Testimony
  - 1. Monitoring
  - 2. Courtroom etiquette
- D. Procedural Law
  - 1. Hearings, trials, appeals
  - 2. Advocacy, burden of proof
  - 3. Subpoenas and affidavits
  - 4. Rules of evidence
- VII. Ethics
  - A. ABC Rules of Professional Conduct
    - 1. Conflict of interest
    - 2. Professional integrity
    - 3. Objectivity
    - 4. Professional obligations
- VIII. Evidence Handling
  - A. Evidence Recognition and Collection
    - 1. Prioritization
    - 2. Sampling
    - 3. Preservation
  - B. Evidence Classes (Class/Individual)
    - 1. Exclusionary evidence
    - 2. Identification
    - 3. Direct vs. indirect evidence
    - 4. Tangible vs. latent evidence
  - C. Evidence Preservation
    - 1. Chain of custody
    - 2. Alteration/degradation
    - 3. Storage (long term/short term)
  - D. Evidence Packaging
    - 1. Proper sealing
    - 2. Types of packaging
- IX. General Science Terms and Principles
  - A. Definitions and applications
    - 1. Scientific method



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- B. General Chemistry Concepts
  - 1. Nomenclature (IUPAC)
  - 2. Type of molecules (e.g., aromatics, isoalkanes)
  - 3. Atomic, molecular weights
  - 4. Acids/bases
  - 5. Periodic Table
  - 6. Elemental composition
  - 7. Bonding
    - a) Ionic
    - b) Covalent
    - c) Hydrogen
    - d) Van der Waals
    - e) Stereoisomer
    - f) Enantiomer
- C. General Biology Concepts
  - 1. Cell structure
  - 2. Genetics
  - 3. Botany
  - 4. Characteristics of body fluids
- D. General Physics Concepts
  - 1. Energy
  - 2. Electromagnetic spectrum
  - 3. Force
- E. General Physiology and Anatomy Concepts
- F. General Statistics
  - 1. Mean
  - 2. Median
  - 3. Mode
  - 4. Standard deviation
  - 5. Variability
  - 6. Population characteristics
  - 7. Confidence Interval
  - 8. Bayesian Theory
- G. Stoichiometry
- H. Logic
  - 1. Critical thinking
  - 2. Inductive and deductive reasoning
  - 3. Contextual bias
- I. Metric System
  - 1. Metric to metric conversion
  - 2. Metric to English conversion

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- X. Forensic Science Applications for Trace (Hairs and Fibers) Analysis
- A. Principles and concepts
1. Properties of hairs and fibers that allow their characterization, comparison, identification
    - a. Phylogenetic characteristics of human hair, common domestic animals, apparel furs, and game animals
    - b. Racial and somatic characteristics of human hairs
    - c. Macroscopic and microscopic features of hair
    - d. Chemical treatments to hairs
    - e. Hair diseases and environmental damage to hair
    - f. Hair structure and microstructure
    - g. Hair chemistry
    - h. Biology of hair growth and loss (deposition)
    - i. DNA in animal and human tissue and hairs
    - j. Biology of vegetable fibers
    - k. Microscopic structure of natural fibers and mineral fibers used in textiles, cordage, and other applications
    - l. Chemistry of mineral fibers
    - m. Chemistry of manufactured fiber polymers
    - n. Manufactured fiber production
    - o. Microscopic features of man-made fibers
    - p. Dyes and additives used in fibers and textiles
    - q. Man made fiber spinning and forms
    - r. Fiber mechanics and damage
  2. Suitability of hairs for nuclear or mitochondrial DNA analysis
  3. Methods of production/manufacture of fibers and textiles and how they affect the product characteristics
  4. Current Information
    - a. Scientific literature applicable to the examination of hairs and fibers
    - b. Attendance at workshops, classes, technical or professional meetings for current manufacturing processes, application techniques, uses, and methods of analysis for fibers
    - c. Critical comparison of old and new techniques in hair and fiber analysis
- B. Occurrence of Hair and Fiber Evidence
1. Loose fibers
  2. Textiles
  3. Cordage
  4. Human and animal hairs
  5. Building materials and other industrial uses
  6. Brushes and furs

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- C. Evolution of the discipline
  - 1. History of the development of fibers as forensic evidence
  - 2. History of the use of hairs as forensic evidence
- D. Accepted standards and practices
  - 1. Methods, procedures, tests commonly used in the analysis of hairs and fibers
  - 2. ASTM, SWGMAT, NIST, SWGDAM
- E. Process Analysis
  - 1. Evaluation of other trace evidence (dust, aggregates, pollen, blood, cosmetics, paint, etc.) found with hair and fiber evidence
  - 2. Consideration of the effects of environmental and mechanical damage to hairs and fibers
  - 3. Consideration of the meaning of the deposition of hairs and fibers including transfer (primary and secondary) and plucking
  - 4. Consideration of retention and/or persistence properties with respect to hairs, fibers, and the pertinent substrates
  - 5. Case evaluation to ensure the analysis addresses the relevant forensic issues
  - 6. When appropriate, determination of the growth phase of a hair, whether forcibly removed, suitability for DNA analysis, artificial hair treatments
  - 7. Development of an analysis strategy for the hair and/or fiber evidence
- F. Results and Conclusions
  - 1. QA/QC
    - a. Use and maintenance of hair and fiber reference libraries
    - b. Verification of associations
  - 2. Reporting
    - a. Construct a report which may include: chain of custody information, description of hairs/fibers, nature of analyses, results of tests, conclusions
    - b. Justification for opinion (positive or negative association or an inconclusive result)
    - c. Case Management
      - a. Maintenance of documents and data for discovery
      - b. Technical review
- G. Light Microscopy
  - 1. Theory and Application
    - a. Principles of light microscopy
    - b. Nomenclature
    - c. Types of light microscopes



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- d. Optical properties of trace evidence materials such as refractive indices, birefringence, color, etc.
2. Procedures and Methods
  - a) Illumination techniques such as polarized light, phase contrast, differential interference contrast, incident and reflected light, fluorescence, darkfield, brightfield
  - b) Characterization and comparison of hairs/fibers by light microscopy
  - c) Making microscopical measurements
  - d) Mounting media
  - e) Photomicrography
  - f) Cross sectioning and longitudinal sectioning techniques
3. Results and Interpretation
4. QA/QC
  - a) Optimization of illumination and alignment
  - b) Maintenance of the microscope
  - c) Measurement of standards
  - d) Comparison of standards across a comparison microscope
- H. Infrared, Raman, Visible, Ultraviolet, Fluorescence, Near Infrared spectrometry
  1. Theory and Application
  2. Procedures and Methods
  3. Results and Interpretation
  4. QA/QC
- I. Electron microscopy (scanning and transmission)
  1. Theory and Application
  2. Procedures and Methods
  3. Results and Interpretation
  4. QA/QC
- J. Gas Chromatography with various detectors and sample introduction techniques (mass spectrometers, pyrolysis)
  1. Theory and Application
  2. Procedures and Methods
  3. Results and Interpretation
  4. QA/QC
- K. Other techniques used in hair and fiber analysis
  1. LC/MS and CE/MS for dyes/additives
  2. TLC for dyes



## Study Guide for the Trace Evidence Examination- Hair and Fiber

### References

Listed below are the references for the Hair and Fiber certification exam. Some exam questions may have been drawn from a variety of other sources including general instrumental or chemistry texts. Similar information may be obtained by studying earlier or later editions of the listed works, as well as other works covering the same topics.

#### *Core (40% of exam content)*

The following texts were used for the generation of test questions for the core knowledge. Applicants are encouraged to familiarize themselves with information provided by these texts as that information relates to the KSA (knowledge, skills, and abilities) outlined in this study guide.

*Techniques of Crime Scene Investigation*, 7<sup>th</sup> Edition, by Fisher, B.J. (Boca Raton: CRC Press, 2004) ISBN 0-8493-1691-X.

*Criminalistics, An Introduction to Forensic Science*, 7<sup>th</sup> Edition (or higher), by Saferstein, R. (Upper Saddle River, NJ: Prentice Hall, 1998) ISBN 0-13-592940-7.

*Forensic Science Handbook, Volume I*, 2<sup>nd</sup> Edition, edited by Saferstein, R. (Englewood Cliffs, NJ: Prentice Hall, 2002) ISBN 0-13-091058-9.

*Forensic Science Handbook, Volume II*, 2<sup>nd</sup> Edition, edited by Saferstein, R. (Englewood Cliffs, NJ: Prentice Hall, 2004) ISBN 0-13-112434-X.

*Forensic Science Handbook, Volume III*, edited by Saferstein, R. (Englewood Cliffs, NJ: Prentice Hall, 1993) ISBN 0-13-325390-2.

*Fundamentals of Forensic Science*, by Houck, M., Siegel, J. (Burlington, MA: Elsevier Academic Press, 2006) 0-12-356762-9.

*Forensic Chemistry*, by Bell, S., (Upper Saddle River, NJ: Pearson Prentice Hall, 2006) ISBN 0-13-147835-4.

“The Rules of Professional Conduct” supplied by the American Board of Criminalistics.

*ISO/IEC 17025: General requirements for the competence of testing and calibration laboratories*. International Organization of Standards, (ISO copyright office, Switzerland, 2005)



## Study Guide for the Trace Evidence Examination- Hair and Fiber

*Discipline-specific (60% of exam content)*

In addition to the core trace evidence information provided in the text above, the following texts were specifically used for development of the discipline specific (hair and fiber) portion of this exam.

*Polarized Light Microscopy* by McCrone, W., McCrone, L., Delly, J. (Chicago, Illinois: Microscope, 2005) ISBN [0250402629](#).

*Atlas of Human Hair: Microscopic Characteristics*, Ogle, R. and Fox, M. (Boca Raton, Florida, CRC Press, 1999). ISBN 0-84938134-7

*Forensic Examination of Fibres*, Second Edition, Edited by Robertson, J., and Grieve, M. (Philadelphia, PA, Taylor & Francis, 1999).

*Forensic Examination of Hair*, Edited by Robertson, J. (Philadelphia, PA, Taylor & Francis, 1999).

SWGMAF Forensic Human Hair Examination Guidelines, US Dept. of Justice, April 2005

ASTM No. E2224-02 Standard Guide for Forensic Analysis of Fibers by Infrared Spectroscopy

ASTM E-620-04 Standard Practice for Reporting Opinions of Scientific or Technical Experts.

ASTM E 2225-02 Standard Guide for Forensic Examination of Fabrics and Cordage.

ASTM E 2228-02 Standard Guide for Microscopic Examination of Textile Fibers

*Forensic Science Communications* April 1999 Volume 1 Number 1, Introduction to Forensic Fiber Examination Guidelines, FBI, April, 1999.

*Color Atlas and Manual of Microscopy for Criminalists, Chemists, and Conservators* by Petraco, N. and Kubic, T., (Boca Raton, Florida, CRC Press, 2003) ISBN 0849312450.

A new generic fiber type, *Forensic Science Communications*, 56(3):2003 Author: Heather A. Velez

Microscopy of Hair Part 1: A Practical Guide and Manual for Human Hairs, *Forensic Science Communications*, 6(1):2004



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**From the Core readings listed, especially close attention should be paid to the following:**

*Forensic Science Handbook, Volume I*, 2<sup>nd</sup> Edition, edited by Saferstein, R. (Englewood Cliffs, NJ: Prentice Hall, 2002) ISBN 0-13-091058-9:

- Chapter 3 *Forensic Applications of Mass Spectrometry*
- Chapter 5 *Foundations of Forensic Microscopy*
- Chapter 6 *Visible Microscopical Spectrophotometry in the Forensic Sciences*
- Chapter 7 *The Forensic Identification and Association of Human Hair*

*Forensic Science Handbook, Volume II*, 2<sup>nd</sup> Edition, edited by Saferstein, R. (Englewood Cliffs, NJ: Prentice Hall, 2005) ISBN 0-13-112434-X.

- Chapter 3- *Forensic Capillary Gas Chromatography*
- Chapter 5- *Microscopy and Microchemistry of Physical Evidence*
- Chapter 6- *An Introduction to the Forensic Aspects of Textile Fiber Examination*

*Forensic Science Handbook, Volume III*, edited by Saferstein, R. (Englewood Cliffs, NJ: Prentice Hall, 1993) ISBN 0-13-325390-2.

- Chapter 2- *A Guide to The Analysis of Forensic Dust Specimens*
- Chapter 3- *Forensic Applications of Infrared Spectroscopy*
- Chapter 4- *Infrared Microscopy and its Forensic Applications*



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### Sample Questions

1. Which of the following best describes the value of field kits for the chemical testing of controlled substances?
  - A. They remove the necessity for laboratory analysis.
  - B. They are presumptive tests.
  - C. They have questionable reliability.
  - D. They allow the officer to make a field identification.
2. The primary reason for proving “chain of custody” on a particular item in court is to:
  - A. authenticate the item.
  - B. Show how many people handled the item.
  - C. Show how long it was in each person’s possession.
  - D. Deter or prevent unauthorized individuals from handling the evidence.
3. Which of the following actions is not forbidden by the ABC Rules of Professional Conduct?
  - A. Embellishing one’s qualifications when testifying.
  - B. Utilizing a secret method.
  - C. Refusing to honor a subpoena duces tecum.
  - D. Interpreting equivocal results based only on an employer’s wishes.
4. Which of the following garments would be the most suitable for collection of trace evidence by using a tape lift technique?
  - A. Nylon shell windbreaker
  - B. Mohair sweater
  - C. Cotton/polyester blend dress shirt
  - D. Pair of blue denim trousers
5. What is pheomelanin?
  - A. A reddish-brown to yellow pigment occurring in hair.
  - B. A sulfur-containing fibrous protein.
  - C. A condition of hair characterized by brittle hair with a clean break.
  - D. A brown pigment occurring in hair.

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6. Consider the hypothetical cylindrical fiber 15 micrometers in diameter, which has  $n(\text{perpendicular}) = 1.570$ , which exhibits parallel extinction and a first order red interference color (in its center) at the position of maximum brightness. When the fiber is aligned perpendicular to the slow ray of the compensator (quarter wave plate), a blue color is noted. For the purposes of this question assume that the optic axis lies along the fiber axis. The  $n(\text{parallel})$  for this fiber would be approximately:
- A. 1.575
  - B. 1.515
  - C. 1.535
  - D. 1.605
7. A graying hair is often associated with:
- A. decrease in diameter
  - B. an increase in diameter
  - C. shouldering
  - D. undulation
8. The property of an optically anisotropic substance by which it exhibits different brightness and/or color in different vibration directions is called \_\_\_\_\_.
- A. dispersion
  - B. pleochroism
  - C. isotropic
  - D. extinction
9. A new fiber whose generic name is polylactide, known as PLA, is based on:
- A. lactic acid esters from naturally occurring sugars
  - B. a new variety of a fluorinated hydrocarbon-based fiber
  - C. a reduced polyamide polymer
  - D. recycled paper fibers
10. An animal hair with an undulating shaft and a wine-glass shaped root is MOST likely to be from a \_\_\_\_\_.
- A. rabbit
  - B. dog
  - C. cat
  - D. deer